THE TECH ENGINEERING NEWS

Massachusetts Institute of Technology • 1938 • *February*

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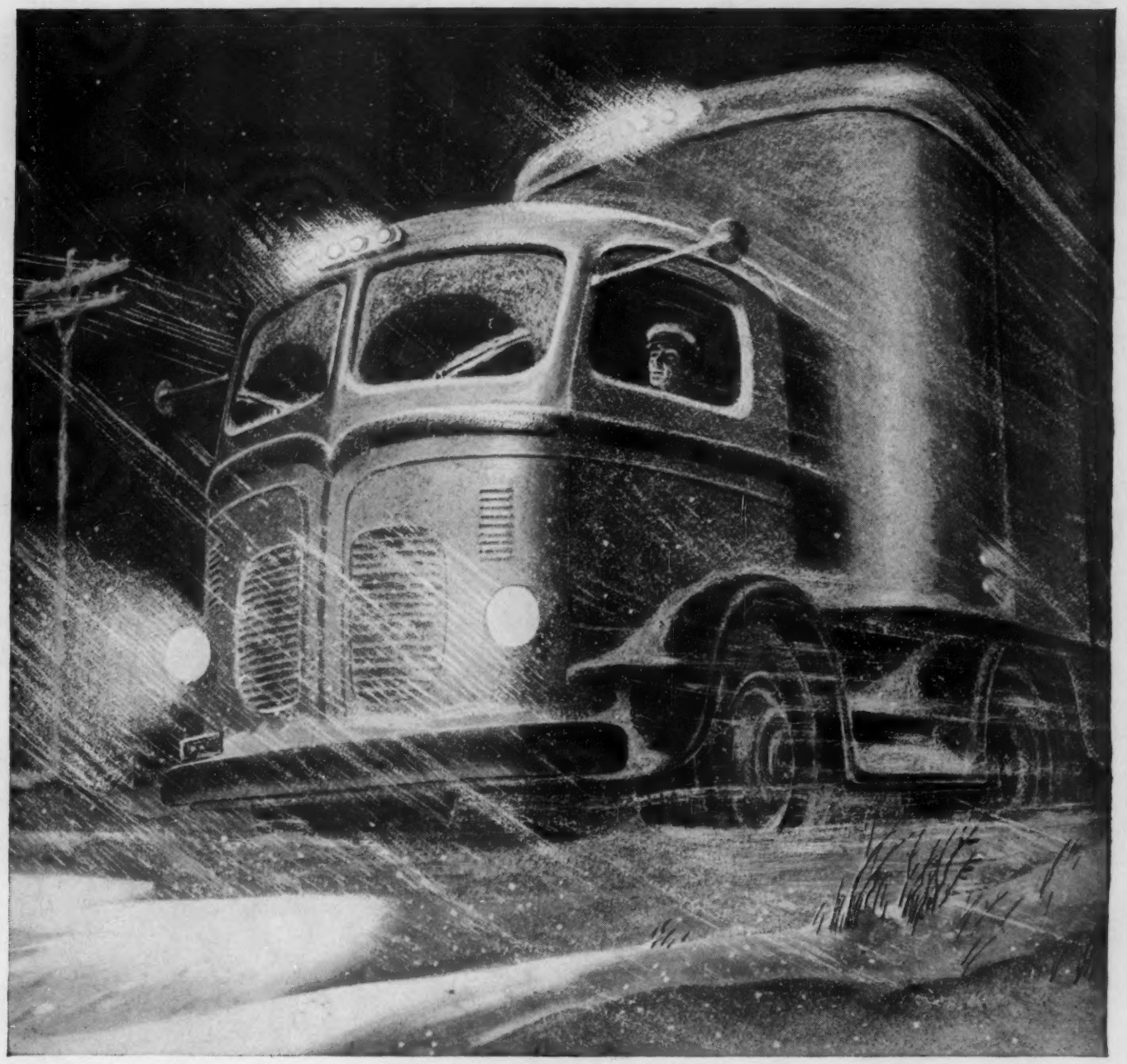

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AUTHORS

FRANK ROY FRAPRIE, author of *The Development of the Photographic Camera,* was born in Fall River, Mass., in 1874. He has been the editor of *American Photography* magazine since 1905. He attended Harvard University, where he received his B.S. and S.M. degrees, and also the University of Munich. Mr. Fraprie received the gold medal of the Vienna Photographic Society for preëminent achievement in 1933; he is also a fellow and medalist of the Royal Photographic Society of Great Britain.

DR. AVERY A. ASHDOWN, an organic chemist and professor at M.I.T., received his early education in the public schools of his home town, North Collins, N. Y. He received a Bachelor of Arts Degree from the University of Rochester in 1914 and his Masters degree two years later. He was an instructor in chemistry at the University of Rochester from then until 1920 when he came to M.I.T. as a graduate student. He received the degree of Doctor of Philosophy in organic chemistry here in 1924, and then spent the next year abroad studying at the Institute of Technology of Zurich, in Switzerland. In 1930 he returned to M.I.T. as a research associate in organic chemistry and has been teaching here since then. He wrote the article on *Dye-Sensitized Photographic Emulsions.*

DR. DEANE ROWLAND WHITE wrote the article *Fine Grain Development.* Since 1927 Dr. White has been associated with the du Pont Film Manufacturing Company where he is now Chief Physicist. Previous to this date he received his B.S. degree from the Baldwin-Wallace College in 1922 and his Ph.D. at Columbia in 1927 where he served as an instructor in physics during the two preceding years. Dr. White is exceptionally qualified for writing because of his extensive work in the sensitometry of photographic materials and his work concerned with radiations from mercury vapor below the ionization potential.

OSCAR EDWARD CANTOR, who wrote the article on the control of *Processing Positive Motion Picture Film,* attended Massachusetts Institute of Technology as a student of general engineering. He was graduated in 1934 with an S.B. degree. At present he is working with the Consolidated Film Industries Inc., at Ft. Lee, New Jersey.

PREVIEWS

Next month, in contrast to this special issue devoted to photography, we will again present articles on a variety of subjects. The science of seeing will be called to our attention by Dr. Matthew Luckiesh, Director of the General Electric Company's Lighting Research Laboratory at Nela Park, Cleveland. In his article, *This Half-Seeing World,* he emphasizes the folly of man, who strains his eyes, intended for work in daylight, by working in poorly lighted rooms. A non-technical but timely subject is discussed in *Low Income Housing* by Peter Grimm. A graduate of Columbia University, Mr. Grimm entered the real estate business in 1911. He is now President of William A. White and Sons, the New York realtors who assembled for Mr. Rockefeller the enterprise now known as Rockefeller Center. An article which promises to be interesting in that it will present several heretofore unpublished facts about Polaroid has been written by Marc Cutler, '39, for our March issue.

In the near future we will publish *Organic Chemical Synthesis Yesterday and Today,* in which C. M. A. Stine will describe the important part that this branch of chemistry plays in our lives, and what some of the new developments are. Mr. Stine, who is Vice President of the E. I. du Pont deNemours Company, has often lectured and written on similar subjects.

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Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

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THE TECH ENGINEERING NEWS
OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Volume XIX Number 1

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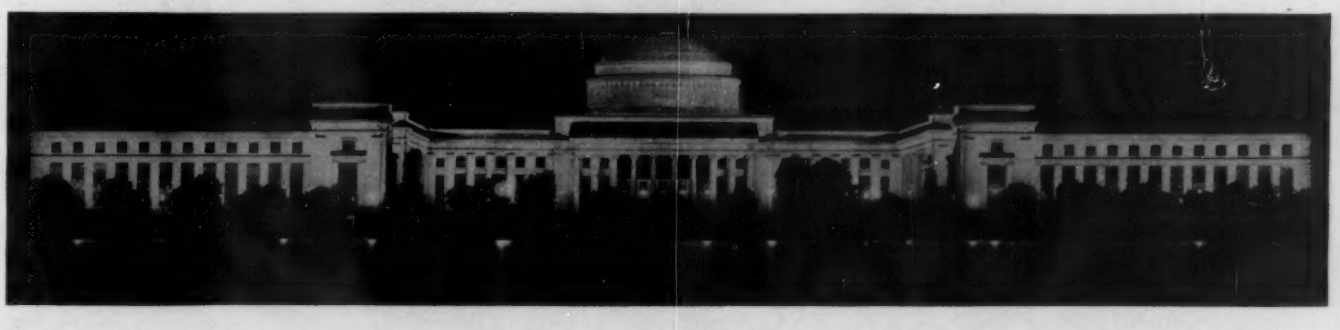
Our Cover This Month

The photograph of the front of the Masonic Temple in Quincy, Massachusetts, which appears on the cover of the magazine, was taken by Charles H. M. White, '22, with a Leica Camera, Summar f2 lens, at f6.3 and an exposure of 1/100 second on DuPont Superior film.

—Courtesy E. Leitz, Inc.



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POWER

Fine Grain Development

Variations In Grain Fineness Brought About By Varied Developers

DEANE ROWLAND WHITE

THE past few years have seen great activity in the study of fine grain development, particularly in its applications to negative emulsions. The increased emphasis on this particular phase of the general problem of photographic development has been largely due to the introduction and practical use, in amateur and professional work, of the high grade small cameras. Another force, tending in the same direction, is the continued effort to secure fine grain in motion picture photography. These forces have not always been separate and distinct as each advance in one field is immediately considered for the other. However, the problems are not quite identical, and it has not always been possible to apply parallel methods under the different working conditions.

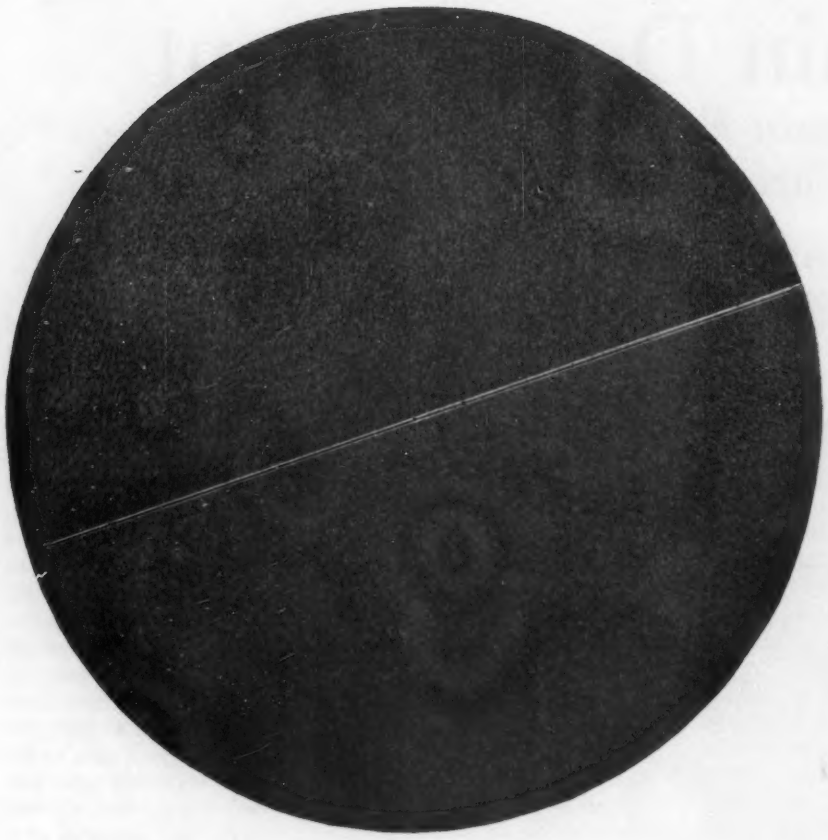
Before considering the more recent attempts at producing fine grain developers, a brief review of developer constitution and function is in order. Developing solutions consist of a reducer or developing agent, a preservative, usually sulfite, an accelerator—an alkaline material—and a restrainer, usually potassium bromide. As is well known, reducers, which are developers, are those compounds which preferentially reduce exposed silver halide to silver faster than they reduce the unexposed silver halide of the emulsion. These compounds are usually readily oxidized by the air, and hence a preservative is used to protect them in solution. Sodium sulfite is used almost universally in this role. The reducers act more rapidly as the alkalinity of the solution increases, hence the term accelerator for alkaline compounds added to control the pH of the solution. Many different compounds have been used for this purpose—borates, carbonates, phosphates and hydroxides being among the most common. In many developing solutions potassium bromide is added as a fog restrainer, since greater differentiation can be thus obtained between exposed and unexposed silver halide.

In addition to the basic functions and actions indicated, certain other characteristics have proved of particular interest. Photographic emulsions of the type used for negatives, either motion picture, roll or cut films, or plates consist of a suspension of silver bromide grains in a gelatine medium. The sizes of the individual grains have been reduced by improvements of manufacture during the years, until at the present time the greatest dimension of the larger grains of first grade negative emulsions is of the order of two ten-thousandths of an inch. Moreover, the size of an average grain is considerably smaller since the smaller grains are of much more frequent occurrence. In an ideal case these grains would develop absolutely independently, and as the final silver particle usually is similar in size to the parent halide grain, an image made up of extremely fine units would be expected. Unfortunately, this simple ideal condition does not exist. It has been shown that in some cases of grain groups or clumps, an entire group develops from what is effectively the exposure of one grain. From this and other causes the final image is found to consist of a grain structure much coarser than the individual grains. The present efforts toward fine grain development appear primarily as attempts to control and minimize this clumping of the grains.

In view of this phase of the problem, some of the special characteristics of different compounds in the developing solution have been studied closely. The results reported have often been contradictory in the extreme, and any attempt to correlate and find agreement in *all* of the different reports appears doomed to failure. At times the different writers become almost acrimonious in their writings, and one might suspect occasional occurrence of an unscientific tendency or bias trying to support some view-point rather than complete impartiality. Attempts have been made to correlate the "graininess" produced by a particular developing agent with its activity as developer, measured by its reduction potential. These attempts have not been successful, and there appears little or no correlation between the reduction potential of a developer and the "graininess" produced, though the one developing agent of current importance for which inherent fine grain characteristics have been demonstrated is the low potential developer, paraphenylenediamine. The tests of other compounds have not yielded satisfactory evidence of specific effect on "graininess." However, an important service has been rendered by this and other work, well establishing the point that low contrast, i.e. low gamma, tends to produce fine grain. This observation has led to the statement by some workers that fine grain is nothing but low gamma. This statement appears to be a definite over-simplification, but it is an important point as the trend is real and definite, even

—Illustrations Courtesy Leica Photography.

This 20 diameter enlargement shows the effect of different developers on grain size.



A section of a 25 diameter enlargement made from ultra-speed film developed in a fine grain developer.

with the special formulae produced.

The entire function of sulfite in a developing formula has not been completely established, but it has been shown to occupy a much more important position than its usual classification as preservative suggests. Developers without sulfite have greatly reduced developing power and several modes of action have been suggested to explain this. It is believed to form compounds with some reducers, these compounds being stronger reducers than the parent substances. It is characterized as a halogen acceptor in describing the reduction reaction. In addition to these effects, it is a rather weak silver halide solvent, and this characteristic has been suggested as most important in considering its effect on "graininess." The mode of action suggested is this: The solvent action of the sulfite tends to increase the spacing between grains and reduce their clumping. Regardless of the correctness of this suggestion, the currently used motion picture negative developing baths are typified by relatively high sulfite content, low reducer concentration and pH maintained by borax, or borax and boric acid at such level that the developing time is eight to ten minutes for the contrast desired. Metol and hydroquinone are the reducers usually used, but no specific fine grain characteristics are ascribed to them under these conditions.

The single, generally credited exception to the general conclusion that reducers have no specific fine grain action is paraphenylenediamine. Consequently there have been many attempts to utilize it, but they have in general encountered two difficulties:

1. The toxicity of the material. (This trouble can be readily avoided.)
2. The low effective emulsion speed obtained with it.

Ordinary care to avoid undue physical contact with the chemical as powder or in solution is the obvious key to the successful handling of this compound when desired, so far as its toxicity is concerned. Its photographic use is but a small part of its industrial application and hence there is a much wider base of knowledge of its health hazard than furnished by its more limited application in the photographic field.

The second obstacle has been a more serious technical deterrent than the first, as it has proved to be difficult to maintain the fine grain image desired and yet obtain photographic speeds comparable with those given by more active developers, such as the borax negative developers mentioned. The attempts most widely credited with success are those involving the addition of glycin as a second reducing agent in the solution. Sensitometric tests have not shown an increase in speed quite sufficient to match speeds obtained at equal contrasts in borax developers, but the difference remaining is so small that in many practical tests it has been negligible.

The literature records many other additions to paraphenylenediamine developers. Two classes of compounds have received particular attention. They are:

1. Additional reducers
   - Metol
   - Hydroquinone
   - Pyrogallol
   - p-aminophenol
   - Pyrocatechol
   - "Rubinol" (Alkyl-substituted Pyrogallol)
   - Rescorcinol

The purpose of the second reducer has been to obtain a more active combination than the paraphenylenediamine alone, and yet retain fine grain characteristics for the combination.

2. Alkaline Agents
   - Sodium carbonate
   - Lithium hydroxide
   - Di-sodium phosphate
   - Tri-sodium phosphate
   - Ammonium hydroxide
   - Ammonium carbonate
   - Potassium carbonate
   - Sodium meta-borate
   - Acetone

The various conditions of alkalinity were tested to secure the maximum activity for the developer concomitant with fine grain. This is of special interest as paraphenylenediamine formulae are notable for the protracted developments suggested. Some success has been attained, but there seems to be a tendency to increase grain somewhat as developing speed is increased in this way. This is very probably due to the increase in softening and swelling of the gelatine under the conditions of greater alkalinity.

Other compounds have also been added to paraphenylenediamine developers. In some cases, the reasons suggested in publications concerning them have not been compelling, but the range covered is of some interest.

Agents added for various purposes:

- Sodium sulfate
- Sodium bisulfite
- Sodium nitrite
- Sugar
- Nickel chloride
- Nickel ammonium sulfate

(*Continued on page* 22)

Processing Positive Motion Picture Films

OSCAR E. CANTOR

THE motion picture producer and director are artists, whose medium is the projected motion picture. The ultimate function of the motion picture laboratory is to produce photographic positive prints, which, when projected to the theatre screen, will convey the visual concepts which director and producer wish to convey.

Some large motion picture producers maintain their own laboratories; others purchase their printing service from large service laboratories catering to the industry in general. The processes described herein refer to the practice of the world's largest motion picture laboratories, those of Consolidated Film Industries, Inc., located at Fort Lee, New Jersey, in which are made approximately one-fourth of all of the prints used by American motion picture theatres.

The average motion picture feature is approximately 8,500 feet long, and from 150 to 500 prints are required for national distribution. Many prints for foreign distribution are also made in domestic laboratories.

The negatives are made by the producer, usually in Hollywood. The raw stock consists of an unexposed positive photographic emulsion, carried upon a base consisting principally of cellulose nitrate. It is secured from the manufacturers of sensitive photographic materials, in 1,000 foot rolls, 35 millimeters in width, and with 64 perforations or sprocket holes per foot on each side of the film

The problems of processing small amounts of film differ radically from those occurring in the processing of large quantities. In a small laboratory, personal judgment may satisfactorily control the entire process, from raw stock to final print. In a large plant where more than a million feet of film is processed every day, the element of personal judgment must be eliminated to the greatest extent possible; since errors in judgment will cause deviations from the desired quality.

It is neither possible nor desirable to standardize aesthetic taste, and no attempt in this direction is made by the laboratories. However, once a print having the proper qualities is produced, it is necessary that conditions of processing are so controlled that all subsequent prints shall be equally as pleasing.

In "Continuous Processing," as practiced in the laboratories mentioned, the rolls of raw stock are mounted at one end of the processing machine, and pass in a continuous ribbon through the printing machines, developing baths, fixing baths, wash tanks, and drying cabinets to the projectors, where the final results are viewed by quality-inspectors.

Before the actual start of the mass production of the release prints, sample prints of the picture are made, to determine the correct exposure of each scene and the best overall contrast to give the best overall artistic reproduction. Variations in the speed of the raw stock are compensated for by changes in printing machine exposure, while variations in the contrast are accomplished by changes in time of development. When the desired standard quality has been achieved in a sample print, the laboratory must be prepared to turn out from 100 to 500 additional prints, all of which must show no noticeable variation from the approved sample. It is practically necessary, in making large number of prints, to use raw stock coated with photographic emulsions from different batches, and thereby having slightly different speed contrast and other characteristics. It is also necessary to use many different printing machines and developing machines in order to meet the service requirements. Obviously, therefore, any satisfactory control system will provide for the standardization of, or systematic compensation for, variation in these various elements. This control is based primarily upon application of the principles of the rapidly developing science of sensitometry.

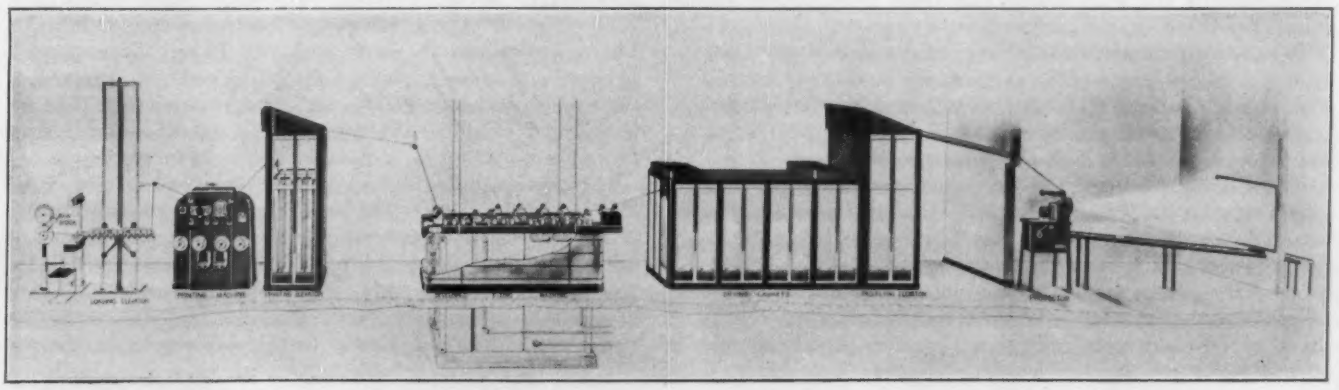
In the control of the modern laboratory, it is essential to have some instrument which will give a series of exposures which can be easily duplicated at any time. The Eastman II-B sensitometer has been found to satisfy this need. The sensitometer is essentially an instrument consisting of a light source, and some means of controlling the exposure on the photosensitive material being tested. The exposure (Ex) may, for practical purposes, be considered the product of the illumination (E) and the time (t) or:

$$Ex = E\,t$$

This "Reciprocity law" is not strictly accurate, and must be modified for quantitative work. However, unless an extraordinary range in lengths of exposure is encountered, it is a satisfactory approximation for use in controlling the behavior of photo-sensitive materials.

It is clear that the exposure may be varied either by change of illumination or change of time. Sensitometers in which the

This diagram shows the progress of the film from the time it enters the printing machine until it is projected for approval before being released.



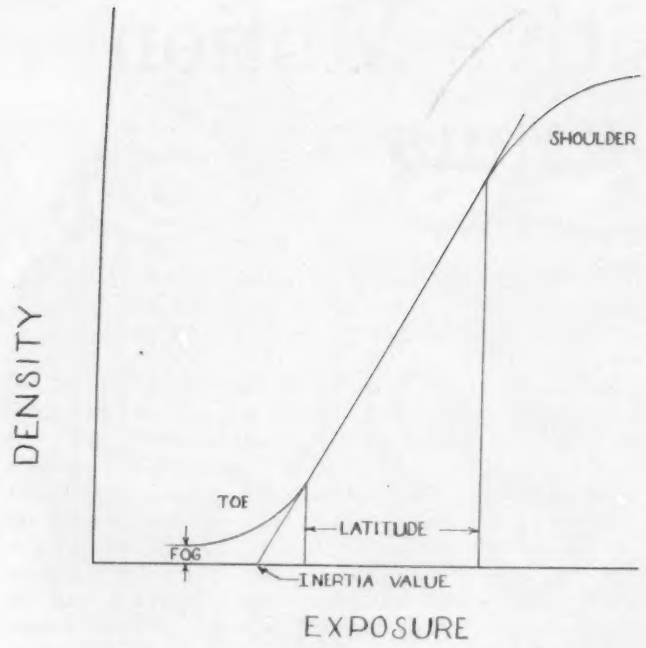


Figure 1

illumination varies and the time is constant are usually referred to as type I, or "intensity scale" sensitometers. Those in which the time factor is varied and the illumination is constant, are referred to as type II, or "time scale" sensitometers. Sensitometers which give the sensitive material a series of separate exposures for each frame are of the intermittent type, or "type A." Type A sensitometers, however, have given way to the non-intermittent type, or "type B," since it was found that the photosensitive material would not integrate the successive exposures, so that the effect of the sum of the separate exposures was not equivalent to the effect of a single exposure of the same total duration. The II-B sensitometer, therefore, produces a time scale type of exposure, in which the illumination is constant, and the exposure is non-intermittant.

The type II-B sensitometer consists of two standard lamps operating well under their rated amperage, emitting radiation at a color temperature of 2600°K for positive work; while for negative work, they are operated to produce a color temperature of 2360°K. It is desirable to use radiation which approximates the light-quality to be used in exposing the photosensitive materials. Consequently, light-filters are used which have such selective absorption characteristics that, when used with their respective lamps, give the desired color-temperatures. For negative materials, the lamp-filter combination produces a color temperature of 5400°K, which approximates mean noon sunlight; while for positive materials, a color temperature of 3000°K is used. This is practically equivalent to the light commonly used in machines for printing positive motion picture film.

The exposure time modulator consists of a slotted drum run by a synchronous motor. The openings in the drum are so cut that in a single revolution an exposure scale can be printed on the sensitive material, consisting of 21 consecutive steps, the exposures of which increase by powers of $\sqrt{2}$.

By means of photographic sensitometry, constants are obtained graphically, from which characteristics of photographic materials may be computed. Thus, if an exposure is made on the II-B sensitometer and the film developed, fixed and dried, some of the characteristics of the material may be obtained by plotting the exposure as abscissa and the densities resulting from this exposure as ordinates. The curve usually has the shape indicated below. It must be borne in mind that the characteristics are dependent upon the composition and temperature of the developer, the time of development, and the type of radiation used in exposure, as well as upon the characteristics of the material.

In general, there will be a portion of the curve where the points will be on a straight line, indicating a constant ratio between exposure and the resulting density. The region below this straight line portion is referred to as the *toe*, that above as the *shoulder*. The projection of the straight line portion on the abscissa is called the *latitude*, and is a measure of the exposure range over which a constant ratio exists between exposure and density. The *fog* is the density in the unexposed regions. The tangent of the angle that the straight line portion makes with the abscissa is referred to as the *gamma value*, or simply as the *gamma*, which is an indication of contrast. The intersection of the straight line portion with the abscissa is called *inertia value*, or simply, the *inertia*.

In the manufacture of positive raw stock, the cellulose-nitrate base is made first, in the form of a wide sheet of celluloid-like material, approximately .005 inch thick. On this is coated an emulsion consisting of silver bromide, and a small amount of silver iodide, suspended in gelatin. After a period of seasoning, the sheets are slit into 35mm widths, 1,000 ft. long, perforated, rolled and placed in cans. Raw stock which comes from coatings made at the same time are given the same *emulsion number*. *Roll numbers*, identifying the various sheets are also shown, as well as *strip numbers*, which indicate the position of the 35mm width on the sheet. Some manufacturers test the various coatings, and group those with the same photographic characteristics. These are identified by shipping numbers. In general, all rolls supplied by the same manufacturer are closely related in characteristics, but accurate control of laboratory results demands exact knowledge of these characteristics.

Each new emulsion received at the laboratory is tested before use, to determine its photographic characteristics. From each emulsion, eight different roll numbers are chosen at random and tested. The testing procedure consists of making II-B sensitometer exposures on portions of each of the test rolls chosen. At the same time, similar exposures are made on a *standard* stock. This standard has photographic characteristics that are representative of the typical emulsions in use in the plant at that time. In addition to this, the standard is an emulsion whose characteristics fall within certain specified tolerances as to inertia, gamma, latitude, fog, shoulder, and toe.

After making the sensitometer exposures on the standard stock, and on the specimens from the rolls to be tested, they are developed together on the production developing machine at a specified constant time of development. The densities of these sensitometer strips are then read, and the characteristics of each roll are plotted graphically and compared with the standard emulsion characteristics. If the characteristics of the new emulsion do not fall within the specified tolerances, the emulsion is rejected. Emulsions must not only have specified photographic characteristics, but must show uniformity between rolls, or else laboratory control becomes difficult. The rolls are usually fairly uniform. If any discrepancies appear in processing, these rolls are immediately discarded. Each emulsion is rated as to exposure and developing time, so that known small variations from the standard emulsion may be compensated for by standard expedients in processing.

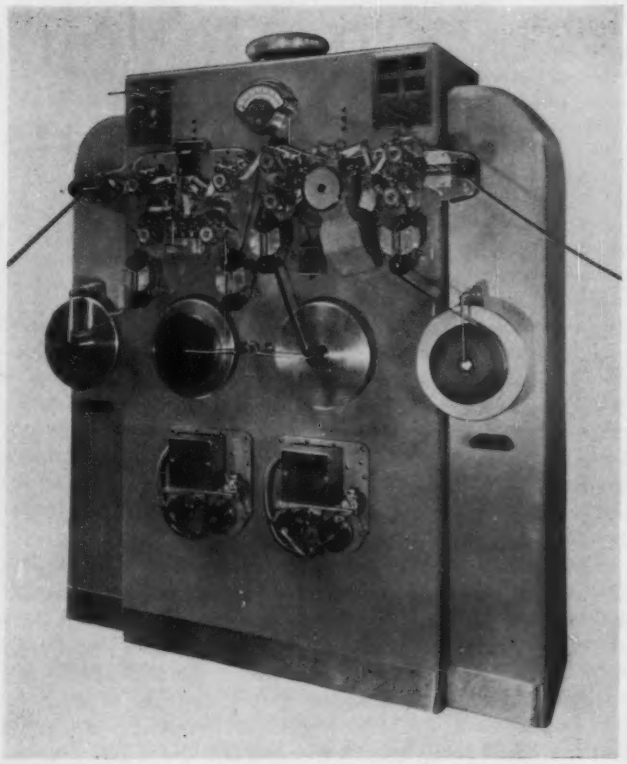
It has been found that some emulsions have an objectionable reciprocity failure. This is an important consideration, for in the production of various types of prints it is necessary to use machines in which the printing speeds and exposure intensities vary considerably. Some printing machines operate at speeds as low as thirty feet per minute, and some as fast as two hundred feet per minute. In the slow machines, the ex-

posure will be relatively long in duration, and the illumination intensitry elatively low. In the fast machines, the converse is true. This means that unless the resulting photochemical effect is proportional to the product of the time of exposure and the intensity of illumination, the speed and contrast ratings of the emulsion will not be the same for all types of printing machines. Emulsions are compared to the standard emulsion for reciprocity failure, by actually printing a *step tablet*, or negative carrying a graduated series of density steps, on printing machines whose time of exposure are the extremes encountered in production. Emulsions in which the reciprocity failure is pronounced are rejected. Fortunately these emulsions are in the minority. Although the laboratory is continually receiving new emulsions from different manufacturers, the characteristics of which are never exactly the same, they can usually be so rated and classified that they may be printed and processed with assurance that the final product will be of virtually uniform projection quality.

In a large laboratory, the large number of printing machines in use produces the problem of maintaining the exposure scales of all machines identical and constant. Because of the amount of film to be printed, it is impossible to print all reels of a picture on the same printing machine. Yet, when the picture is projected in the theatre, it is important that the quality of the picture from reel to reel remain constant. Often it is necessary to make prints from a picture years after its original release. If the exposure scales of the printing machines have varied, it necessitates *re-timing* the negative and making new sample prints, with the consequent expense. The necessity of establishing an invariable standard to which printing machines may be compared to maintain their exposure scales constant is clear.

One of the best available means of duplicating constant densities over a great period of time, is the II-B sensitometer. The II-B time scale is such that there is a wide choice of exposure available, so that it is fairly easy to obtain an exposure step whose exposure time closely approximates that of the printing machine. This is necessary so that any reciprocity failure of the stock will be eliminated. Also, the spectral quality of the filtered light-source of the II-B sensitometer is approximately that of the printing machines.

A negative *step tablet* is printed on all printing machines daily. On this same roll of positive stock, II-B sensitometer exposures are made, and the entire test film is developed at a constant time of development. The print of specified steps in this negative step tablet, if printed on a machine whose exposure scale is correct, will be equal in density to specified steps exposed on the II-B sensitometer. The amount of variation, if any, is a measure of the degree to which the exposure of the printing machine must be increased or decreased as the case may be. As the II-B sensitometer exposures can be duplicated at any time, and as the printing machines are compared to it, the exposure of the printing machine can be maintained at a constant level indefinitely. In this way, the laboratory can at any time use any one of its many printing machines, and yet be assured of uniform exposure and exposure scale throughout the entire plant.



This machine exposes accurately 200 feet of film a minute.

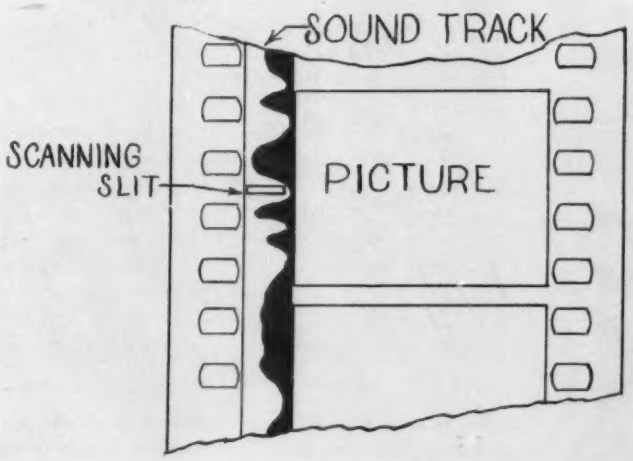


Figure 2

Picture and sound negatives are on separate rolls of film, yet must be printed side-by-side on the same roll of positive stock. The sound quality of any print may be seriously impaired if the sound track is not placed properly in relation to the scanning slit in the projector. It can be seen from the sketch that if the sound track is displaced in printing as in Figure 2, upon projection the peaks of a variable area sound track will be cut off, resulting in a distortion of the original sound. For this reason, there is incorporated in the exposure scale tests, a section of negative by which the placement of the picture and track on the positive may be checked.

Although small changes in the picture placement on the positive are not so detrimental as changes in sound track placement, picture opposition on the film is kept within as rigid tolerances as the sound track. These are measured daily with a microscope, and the tolerance for placement is held at plus or minus three one-thousandths of an inch.

In addition to the control of placement of the sound and picture images, there is the necessity of insuring high definition. A loss of definition in the printing machine may be due to poor contact between the positive and negative, to light scattering in the optical system, to excessive slippage between positive and negative, or to one or more of many other less obvious causes. In order to insure the best definition at all times, a short section of a 9,000 cycle sound negative is in-

(Continued on page 24)

The Development of the Photographic Camera

FRANK R. FRAPRIE

THE photographic camera is essentially a light-tight box provided at the front with an orifice for the admission of light, and at the back with means for holding a sensitized photographic material. The front orifice may be as simple as a mere pinhole, or it may be provided with a lens varying in quality from a simple meniscus achromat to a fast modern anastigmat. More changes have occurred in camera construction in the last ten years than in all its previous history. It may be useful to examine past progress and future possibilities.

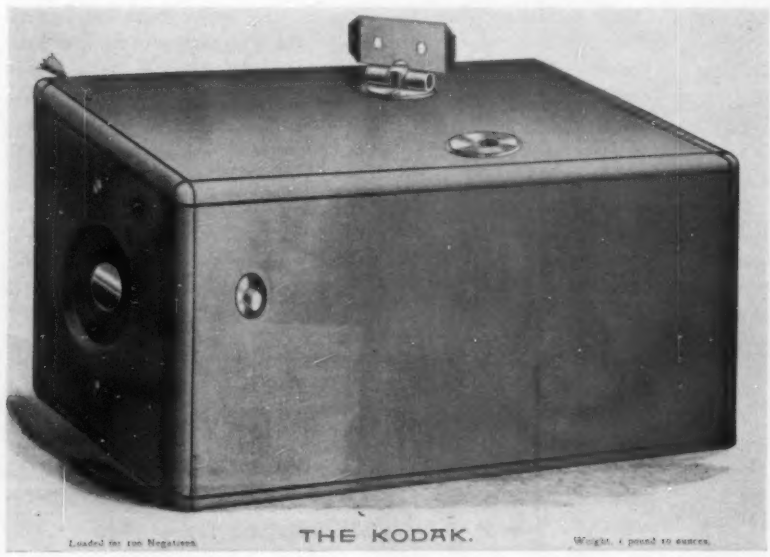
The first notion of the camera dates back to remote antiquity, for images produced by apertures in hangings were noticed upon the wall of a darkened room early in the history of mankind. The artistic genius of the Renaissance led to the invention of the *camera obscura*, a dark room in which the image of outside objects was thrown upon a flat surface by a simple lens, as an aid to sketching. While this was at first in the form of an actual room, portable chambers for the same purpose were devised and were well known to artists when the painter, Daguerre, made his discovery of one of the fundamental photographic processes. His photographic camera consisted essentially of a wooden box with the plate holder at the back and a slow lens, constructed for his purpose by a Paris optician at the front. Several cameras made and sold by Daguerre are still in existence.

Photography, both in the form of the daguerreotype and of various processes which produced a negative from which a paper positive could be made, spread widely and very rapidly throughout the world and became immensely popular, especially for portraiture. In 1840 the Viennese optician, Petzval, calculated the Petzval portrait objective which increased the workable aperture from the *f*:11 or *f*:16 of the early lenses to *f*:4. While this lens had a deeply curved field and consequently fell off considerably in definition toward the edges, the central sharpness was of a quality not surpassed by any other objective, until the production of modern anastigmats, and thus the production of perfectly satisfactory sharp portraits was made possible from the very early days of photography.

Old Style Equipment.

The burdened hiker is taken from an advertisement of about 1887-88, promoting the new "portable dry plate outfits for amateurs." The hiker's kit, an old wet plate outfit, includes field darkroom tent, complete developing outfit, camera, accessories, tripod and perhaps other items.

—Illustrations Courtesy Eastman Kodak Co.



The pioneers of photography, and the scientists and artists who wrote enthusiastically about the new science immediately after its invention, were interested only in the magical perfection of detail possible by the new process. It has been estimated that there were fifteen thousand portrait painters making a living in the decade before the invention of photography. In a dozen years this tribe had been reduced to insignificant numbers and they were replaced by hordes of daguerreotypers. For fifty years the professional photographer was practically the only photographic artist, and the camera suited for his needs, primarily for use in

The Kodak of 1888 held a film roll of 100 exposures (makes the 36-exposure miniatures look sick). It produced circular pictures, about two inches in diameter. Interestingly enough, the film winding was accomplished by a gear arrangement very much like that in today's 35mm. miniature cameras.

The "roll holder" illustration is from the 1886 catalog of the old Eastman Dry Plate and Film Company. It preceded the roll-film hand camera, and was made for use with a plate camera, instead of single plate holders. It held a spool of negative paper.

ROLL HOLDERS.

the studio, was a heavy and bulky contrivance, slow in action. Outdoor photographs were made and there were even amateurs from the very beginning of photography. An amateur in Newburyport built his own camera and ground his own lenses as early as 1841, but the amateur's outfit until the '80's made up a pack which might weigh as much as 60 or 70 pounds.

After the advent of the dry plate about 1880, it became more possible for amateurs to succeed in photography and an era of progress in camera building started. Various forms of box cameras became popular and the so-called hand and stand camera, which was a lighter and smaller modification of the typical studio camera, was developed by various manufacturers. The invention of roll film in 1891 produced the Kodak, and the Kodak with its original slogan, "You press the button, we do the rest", made it possible for the most inexperienced person to produce pleasing photographs as records of travel and of family activity. As long as it was necessary to load the camera with fifty or one hundred films and send it back to the factory for developing and reloading, commercial progress was slow, but the invention of daylight-loading film cartridges greatly widened the scope of amateur photography and it became an engrossing occupation for thousands of photographers throughout the world, many of whom insisted on doing all of their own developing and printing, and who experimented widely in all the physical and chemical fields of photography.

Cameras, however, did not depart widely from their original characteristics, except for the introduction of the reflecting camera, which interposed a mirror between the lens and a ground glass in the top of the camera, so that the photographer could observe his picture until the moment of exposure. This made newspaper photography possible after the invention of anastigmat lenses. The Petzval portrait objective was not satisfactory for outdoor work, because of its optical defects and great weight, and moreover the universally used rapid rectilinear or aplanat, while having a fairly flat field, was confined to a usable aperture of about *f*:8. However, the Goerz Double Anastigmat, now known as the Dagor, and the Zeiss Protar, appearing about 1893, revolutionized the field of speed photography, and strangely enough, gave users of the first anastigmates, instruments whose central sharpness and definition have never been excelled and whose lenses are today standard lenses not inferior to the most modern anastigmats in any particular save speed. These lenses were followed by a flood of others and their apertures of *f*:6.8 and *f*:6.3 were soon surpassed by *f*:4.5, which remained for many years the standard of anastigmatic performance.

During this period of gradual development of lenses, there were no essential improvements in cameras. They continued to be made in the form of simple boxes, of roll film and plate cameras which could be closed to a moderate compass, and of the bulky reflecting camera. Details of design were changed, but essentially the camera was in no sense a precision instrument. Its mechanical construction, if solid, was heavy and bulky, and if light, was impermanent and easily damaged. Amateur photography had periods of popularity as a hobby and intervals of decline, but it remained a hobby pursued by an inconsiderable proportion of the population, a few of whom did their own processing and a majority of whom, in the United States at least, used cameras on holidays and had prints of more or less satisfactory quality produced by commercial finishers and corner drugstores.

In 1924 a German mechanician by the name of Oskar Barnack produced a camera based upon radically different principles from those heretofore known. Having been employed as a builder of microscopes, a domain of optical production where the most stable mechanical construction is essential, he produced a camera built with the utmost mechanical precision, equipped with a metal focal-plane shutter and designed to employ, instead of the conventional film sizes, the 35mm perforated film used for cinematographic purposes. While miniature formats had been employed long before this period, they had never been successful, because the prints

(*Continued on page 23*)

This illustration of an enlarging set-up comes from the 1886 catalog of the old Eastman Dry Plate and Film Company, where it is captioned "Eastman's Enlarging Apparatus in Operation."

Dye-Sensitized Photographic Emulsions

AVERY A. ASHDOWN

IF present-day photographic practic ewere to turn its gaze backward for a few moments and survey the century which has elapsed since its origin in the work of Henry Fox Talbot at Laycock Abbey, Wiltshire, England, certain milestones would be discerned along the line of progress. One of the most important of these landmarks would be found near the middle of the course, in 1891, when the discovery was made that various organic dyes increase the sensitivity of silver salts to the longer wave lengths of light. A little more than a decade later the way was opened for the greatest success which has been recorded in this direction. At that time it was discovered that pinacyanol, a member of the class of organic dyes known as the cyanines, greatly increased the sensitivity of photographic emulsions in the region of the infra-red end of the spectrum. Investigations in the field of this class of dyes were stimulated further in 1906 when the Hoechst Dye Works in Germany introduced dicyanine, chemically related to pinacyanol, and demonstrated its effects. So valuable were the results obtained with this second compound that the conviction grew that within the whole group of the cyanine dyes there might be found certain individuals which would constitute the best means for infra-red sensitization.

The investigations, thus developing, were rewarded in 1919 by the demonstration that kryptocyanine increased the sensitivity of the photographic plate to 8000 Å or far beyond visible red light. With the use of this dye it was possible to make photographs in virtual darkness, using infra-red radiation for "illumination". In 1925 neocyanine, discovered quite accidentally in the process of preparing and purifying quantities of kryptocyanine, produced sensitivity to longer wave lengths, namely: 9000 Å. Six years later, xenocyanine, another of the cyanines, was shown to be even more effective as a sensitizer. By its use the spectral region from 9000 Å to 11,000 Å or more could be recorded on the photographic plate.

The value of these extensions of sensitivity lies, in part, in the greater range given to infra-red spectroscopy. For example, it has been reported that by using the new sensitizers several hundred new lines, some even beyond 13,000 Å, have been photographed in the spectra of the rare gases. Astronomical investigations have been aided by the increased sensitivity. It has improved the effectiveness of aerial photography. It serves the further general purpose of putting into the hands of the experimenter with photography the means for examining the effects of light waves in the region much beyond the visible spectrum. Although the individual sensitizing dyes are often very expensive, the relatively small amounts required, make the cost moderate and well within the reach of the enthusiast.

Two general characteristics of infra-red radiation contribute to the effects which may be obtained by using dye-sensitized plates or films. The great transparency of the earth's atmosphere for the infra-red accounts for the dead black appearance of the clear sky in this kind of photography. By the same token the photographic eye is able to see through ordinary atmospheric haze and distant details appear clearly defined in pictures made by this method. A second effect is produced by the greater reflection which many objects have for infra-red radiation as against visible light. Thus the foliage of many green plants reflects the infra-red perfectly and trees photographed in sunlight appear to be endowed with leaves

The view from White Face Mountain, N. Y., taken with Eastman Infra-red Sensitive Film 1-R

—*Courtesy Radiography.*

Infra-red photograph of dog in fetal membranes; red cinnebar was injected into umbilical artery.

of silver. This effect is less pronounced with the pines and the hemlocks. Real fog and clouds reflect practically all of the infra-red which comes to them. On account of their opacity, cloud banks are often rendered very successfully in this kind of photography. Shadows cast by trees or other objects will appear deep black, whenever the infra-red photographer depends on diffused light from the sky for illumination. In other words, whoever experiments with infra-red photography must be guided in part by what is visible and in part by his knowledge of the reflective powers for the infra-red of such objects as green leaves, patches of white sand, clouds, and fog banks. He must recall, also, the relatively remarkable penetrability which infra-red radiation has for many diverse materials, even for such things as rubber, wood, and the human skin.

New insight into what happens when this remarkable sensitivity is brought about by the cyanine dyes has been furnished by the results of researches carried out by Carroll, Leermakers, and Staud in the laboratories of the Eastman Kodak Company and published in the *Journal of Chemical Physics* of recent date. Previously it had been known that a sensitizing dye of any kind must have affinity for the grains of silver halide and that there are many dyes adsorbed to silver salts which do not confer greater sensitivity. Furthermore, it was appreciated that infra-red light must be absorbed by the dyed halide before the emulsion containing it increased in sensitivity.

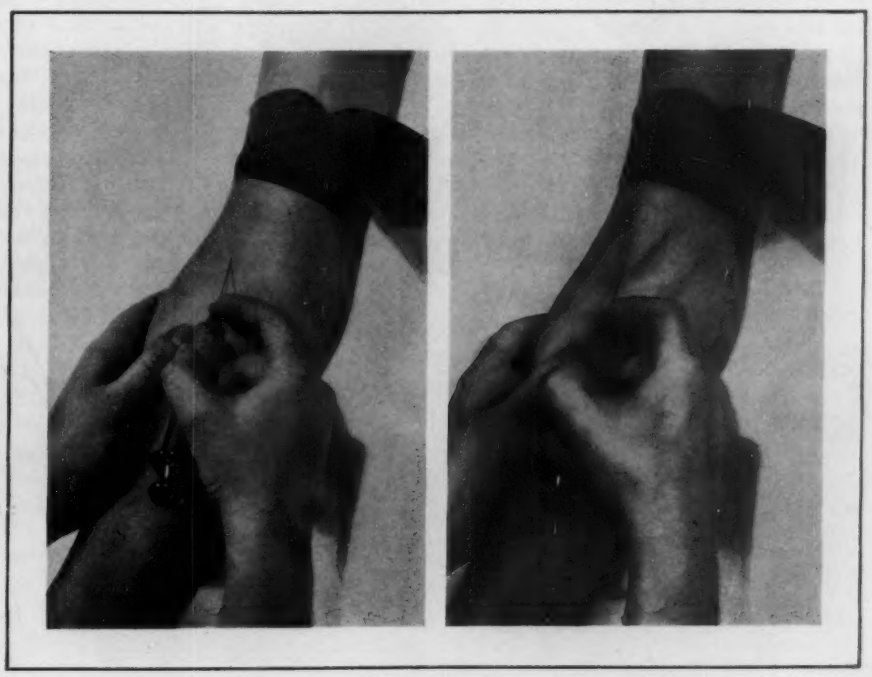
The new data show that in the region of sensitizing there is a direct correspondence between the shape of the light absorption curve of sensitized emulsions and the curve for the spectral sensitivity of these same emulsions. This relationship has been shown to be quantitative for two types of commercial film, the one orthochromatic and the other panchromatic. This close parallelism between the relative absorption and sensitivity curves, particularly in the case of the panchromatic emulsion, is believed to indicate that the sensitivity is directly proportional to the amount of light absorbed. This parallelism suggests, further, that the sensitizing dye acts as an extremely efficient light acceptor for the formation of the latent images. The energy absorbed by the dye is believed to be transferred to the silver halide in such a way that the halide is activated just as if it had absorbed the light energy originally. In other words, it appears that the mechanism for the formation of the latent images is independent of the manner of absorption of light energy, be it either directly by the silver halide itself or indirectly through the intermediate action of a sensitizing dye.

Evidence has been accumulated and reported in the scientific papers to which reference has been made, which shows that the halide ion and not the silver ion controls the adsorption of cyanine dyes to the silver halides. This conclusion has been reached as the result of experiments with the insoluble halides of lead, mercury, and cuprous copper. All of these compounds readily adsorb the various cyanine dyes. Moreover, the light absorption characteristics of these salts, dyed from a water solution, are similar to those of the silver halides, dyed in the same way. Still other experiments showed that insoluble salts of lead and silver which were not halides would not adsorb the sensitizing dyes. These experiments were tried with silver carbonate, oxalate, and phosphate and with lead sulphate and oxalate without effect.

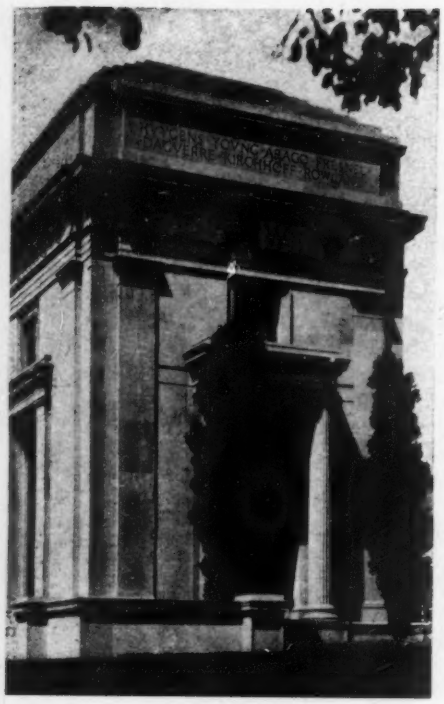
From time to time data have been published which indicate that the state of aggregation of some of the sensitizing dyes affects their light-absorption characteristics. The fact is well known, also, that some cyanine dyes sensitize photographic

(*Continued on page 25*)

—*Courtesy Radiography.*



Ordinary (left) and infra-red (right) photographs showing the veins in an arm during an intravenous injection.



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Editorials

DEDICATION

WE respectfully dedicate this issue of the TECH ENGINEERING NEWS to that friend of the Institute, and pioneer in the development of the modern camera, George Eastman. On this page is a picture of the plaque over the main entrance to the George Eastman Research Laboratories of Physics and Chemistry which were made possible by his generosity.

The Eastman Laboratories are not the only thing he did for Technology. It was through his generosity that the greater part of the money for building the new Technology in Cambridge was raised. We of Technology will always feel grateful to the man who aided in the financing of our Alma Mater at a time when there was grave doubt whether the expansion would be successful, and who since has given generously to aid higher education in the United States.

It is not as a benefactor to education in general, or to Technology in particular that we wish to honor Mr. Eastman, but as the inventor of the transparent, flexible photographic film, and of the first camera to use such a film. Were it not for his primary developments, many of today's photographic marvels would not have been accomplished. One of the greatest sources of public amusement would probably still be struggling along with make-shift devices for producing "moving pictures" on a screen. Edison's "kinoscope" was developed after Eastman had made flexible film available to the men working on the problem of taking and projecting motion pictures.

When George Eastman committed suicide in 1932, he left a note which read:

"To my friends:

My work is done. Why wait?

G. E."

When one surveys the things which Mr. Eastman had done, one wonders whether he might have done much more, but, is at the same time thankful that he accomplished so much.

"Happy is he who has been able to learn the causes of things, and has cast beneath his feet all fears, and in- exorable Fate, and the roar of Greedy Archeron."

—Virgil

USELESSNESS

IN general, student committees around the Institute perform some useful or at least definite function; in fact, such functions are the only legitimate reasons that committees can offer for their existence. Every now and then these functions cease to be effective or are eliminated entirely, but it is seldom that the committee disbands similtaneously with the withdrawal of its objective. If the committee has lived long, it has adopted some more or less complicated form of organization whose officers continue to be elected. With no purpose, its meetings may be few and ill-attended — yet it continues to exist.

At the present time the Combined Professional Societies is just such an organization — existing without any real, vital motive. Organized a good many years ago, its objective was to promote co-operation among the various Professional Societies. It soon became evident that about the only chance for co-operation of the Professional Societies was in the management of Open House. This duty was removed a year ago by the Institute Committee, which set-up a special Open House Committee.

With its main bond eliminated, the C.P.S. fumbled around last year, and tried to organize other co-operative activities in the form of general professional meetings. The meeting concerning the Boulder Dam was a good example of a successful general meeting of this type, but it was expensive. The small societies, with their limited memberships, and consequently limited budgets, became justly indignant about having their treasuries drained by assessments made to cover the financial costs, and the general meetings were dropped.

Now the C.P.S. performs no useful purpose. Its meetings are poorly attended and the prevailing spirit is scarcely co-operative. A recent attempt to amend the by-laws revealed the fact that no record of recent changes in the by-laws and constitution had been made since 1927; these records are presumably "lost." The business is usually haphazard and irrelevent, and the society is degenerate.

The theory of co-operation is fine, but with little opportunity for conflict existing between societies, there is little need for co-operation. There are two possible solutions: Let the C.P.S. discover for itself some worthwhile function, or let it disband. A useless, meaningless activity has no place in the Institute's activity system.

HOBBY SHOP

EVER since the day when someone said, "Tech is a place for men to work and not for boys to play," our Institute has made every effort to provide these men with the opportunity and facilities for the most beneficial forms of play. Nearly every recognized college sport is represented here at school, as well as publication, musical, and dramatic organizations. A new child sired of the Institute made its appearance this month in the form of a student hobby workshop.

The zealous work of some eight students under the very able guidance of Mr. A. C. Watson, of the English Department, has made possible this gem of hobby lovers that now occupies a room in the basement of Building Two. The shop is splendidly equipped with all the necessary tools for fine wood and metal working, a circular saw, jointer, emery wheels, a jigsaw, drill press, wood and metal lathes, and supplementary machinery. We must laud the fine co-operation received from the many departments of the Institute who donated a large part of this equipment, most of which has been reconditioned by the students to look and function like new. The cost of the shop has been and will continue to be a responsibility of the Institute. The only cost to the student workers is that of the principal materials used. If, however, the hobby enthusiast is constructing something for the Institute Museum of Science and Industry this assessment is not made. Mr. Watson is in charge of the growing Museum and can always put a willing student to work or, shall we say play, on some additional exhibits.

This shop has proven and will more and more prove that genius has heretofore wandered undirected and has been unable to expand its abilities into opportunities. Already we see miniature airplane engines, a micro-miniature gasoline engine, a model clipper and locomotive, and a small loom reproduction, all in the process of construction. Several interested students are building an electric furnace which will be used for projected metal spinning.

The need for just such a recreational center was first realized three years ago when an inquiry in the Freshman class was made in an effort to find out the extent of their hobbies. This investigation prompted a freshman hobbies exhibit at the 1935 Open House followed by a larger and more successful hobby show at the following Open House.

Since this present shop is already overcrowded with machinery and tools, it is only hoped that the Institute will expand facilities to provide for the large number of craftsmen who are certain to desire space for recreational projects. This shop is indeed a commendable contribution to the modern movement for the better use of leisure and the development of interesting and useful avocations which bring pleasure and relaxation throughout life.

—Courtesy Explosives Engineer.

RESEARCH IN REVIEW

COURSE XVIII — Mathematics

THE Department of Mathematics is actively engaged in research on a large number of problems dealing with such varied fields as applied mathematics, statistics, topology, geometry, and analysis.

Professor Hitchcock is working on a very interesting and important problem in modern mathematical physics; namely, the study of the energy levels of the helium atom. He is also developing numerical methods of solving algebraic equations with complex coefficients for use in connection with electrical engineering problems; and he is simplifying his numerical methods of solving the Fredholm integral equation. Professor Crout is working on mathematical problems which arise in mechanics, and, in particular, is developing graphical methods of solving stress problems of three dimensional structures. Dr. Wadsworth is making a statistical analysis of depreciation of equipment, and is collaborating with Mr. Seiwell of the Woods Hole Oceanographic Institute in writing a book on the application of statistics to biological research.

A large number of men in the department are at work on problems in the field of analysis. Professor Wiener has a very wide variety of interests and is working, among many other things, on an example of a function with a singular spectrum. Professor Wiener is also collaborating with Dr. Pitt of Harvard University on Tauberian theorems of the Ikehara type, and on reciprocals of absolutely convergent trigonometric development; and he has just completed a paper with Dr. Martin of this department on new and general Tauberian and gap theorems. Professors Rutledge and R. D. Douglass have been investigating the range of de la Vallée-Poussin summation, and are studying certain integral functions which determine this range. Professor Cameron is studying the distribution of values of the Riemann Zeta function, and is collaborating with Drs. Martin and Taylor in research on functionals of random distributions. Dr. Taylor, in addition to the above collaboration, is working on simultaneous difference equations in the complex domain. Dr. Martin is continuing his investigations on analytic functions of several variables and is obtaining theorems of the Phragmén-Lindelöf type; and at the same time is obtaining results of a different type by using Fourier methods. He is also collaborating with Dr. Reissner of the Aeronautical Engineering Department in applying methods of the calculus of variations to a mechanics problem of the buckling of plates. Dr. Levinson is engaged in research dealing with entire functions and also with non-harmonic Fourier analysis.

COURSE VIII
Thermionic Emission From Single Crystals

AS a subject for physical research, the electron combines two favorable and rarely coincidental properties. Its behavior, if proper, has great commercial value, and proper or improper, is of considerable theoretical importance. For one reason or another, a great deal of research has been directed toward the determination of the conditions under which electrons are liberated from matter in general, and from metals in particular.

The most common and convenient method of obtaining electrons is by heating a piece of metal until they "boil" out of it. This phenomenon is called thermionic emission. Classically this view of boiling electrons was an exact picture. The electrons were thought to evaporate from the metal much as water molecules evaporate from a drop. No matter in what direction a electron happened to be traveling through a metal, or which side it came out, the properties of the metal were supposed to be the same. We now realize that in a crystal, this would not be true, as some directions, and the surfaces corresponding to them, have different properties from others. Since all metals are crystalline, the electron emitting properties will depend on the particular face or faces of the crystal which comprise the surface.

The surface of a metal presents a barrier, or potential hill, to the electron. If the electron has sufficient energy, it will pass the barrier and appear on the outside of the metal. The different emitting properties of the different faces of a crystal are caused by different barriers which they present to the electrons approaching them from the interior. Up to the present time, researches in the electron emissive properties of metals have neglected this fact.

Work being done at the Institute under the direction of Professor W. B. Nottingham has for its purpose the determination of the nature and magnitude of the effects of crystal structure on the thermionic emission. Preliminary work done by Drs. R. P. Johnson and W. Shockley indicates that these effects may be of considerable importance, and that they may account, at least in part, for present discrepancies between theory and experiment.

Since accurate measurements on thermionic emission are most conveniently made on filaments, it is desirable to produce them composed of large crystals, each with a principal axis directed along the wire. To produce the desired crystals tungsten wires are drawn to size through dies. This breaks up the existing crystals of the wire so that, on the average, the fragments at the center have a definite orientation, whereas near the surface they are randomly oriented. By appropriate heat treatment it is possible to recrystallize the wire in such a fashion that the fragments at the surface are reabsorbed into crystals growing out from the center, making a few large crystals oriented in a direction along the wire. Thermionic measurements can now be made on such a wire and the crystal effects evaluated.

A limitation on the work with filaments is that not all of the principal crystal faces can possibly be exposed at the same time. In order to surmount this difficulty, other work uses a sphere, composed of only two or three large crystals whose orientation is determined by measurement, and which has been ground, polished, and carefully heat treated. Use of an electron projection system, in which electrons emerging along a given radius of the sphere proceed directly to a fluorescent screen on the interior of a concentric spherical bulb, gives a picture in light and dark patches which correspond to the regions of good and poor electron emission of the tungsten sphere.

COURSE VII — Vitamin D Research

VITAMIN D is a chemical substance which occurs in food substances, notably fish liver oils. It is called a "food hormone," because, like hormones, it has a catalytic effect upon body processes. This vitamin is essential to the formation of bone. Without it cartilage is deposited, instead of a calcium phosphate complex, and a disease known as rickets develops in the bone. Since cartilage cannot support weight, a rachitic child develops bowed legs and a curved spine. There are several other, though less obvious, effects of a deficiency of Vitamin D in the diet.

If certain plant sterols, especially ergosterol, are exposed to selected wavelengths of ultraviolet light, these sterols are converted into isomeric substances which have marked antirachitic properties. Ergosterol was first isolated from a fungus called ergot, which produces a disease in rye plants. Today it is obtained from selected strains of yeast and molds,

grown commercially for this purpose. One gram of the active isomer of ergosterol has so much activity that it will produce measurable healing in the bones of 15,000,000 rats having experimental rickets. It is possible to detect the presence of five hundredths of a millionth of a gram of it in a food substance by animal assay. Until recently it was thought that the Vitamin D in fish liver oil was the same chemical substance as that produced by the irradiation of ergosterol. Physiologically the effect of each form appeared to be the same. By the available chemical tests they were indistinguishable. Chickens have a reputation for being perverse, to their sorrow. By its perversity, the chicken has revealed to vitamin investigators the dissimilarity of these two forms of Vitamin D. To cure its rickets, the chicken requires twenty times as much irradiated ergosterol as fish liver oil. Today we know that the Vitamin D in fish liver oil is mainly an isomer of a cholesterol (animal sterol) rather than ergosterol (plant sterol). The natural animal vitamin is now called Vitamin D_3 and the artificial vitamin produced by ultraviolet irradiation is now called calciferol or Vitamin D_2.

In less than seven years, Professors Robert S. Harris and John Bunker of the Department of Biology and Public Health have used more than 20,000 animals in their vitamin researches. Over a period of several years, accumulated data have shown that irradiated ergosterol (impure Vitamin D_2) produces pathological calcification of the arteries (arteriosclerosis), lungs, kidneys, and liver, if one feeds about 10,000 times more Vitamin D than is needed.

Here at Technology, recent research has shown that the natural D_3 is perhaps half as toxic as artificial D_2. The proof was effected by feeding one group of animals 80,000 units and another group 50,000 units of a concentrate of tuna liver oil (crude D_3) to each rat daily for 40 days. The pathological effects of these feedings were compared with the effects produced by the feeding of 80,000 units and 50,000 units of irradiated ergosterol (crude D_2) daily to two other groups of rats. All tissues were examined histologically.

The administration by mouth of 50,000 International units of irradiated ergosterol (Vitamin D_2) caused more severe calcification of the kidney, stomach, aorta, and heart than 30,000 International units of tuna liver oil (Vitamin D_3). This is the first demonstration in the same animal of a physiological difference in the two most common forms of Vitamin D.

Experiments are now under way in which the toxic effects of these two vitamin forms is being measured by chemical, rather than histologic, techniques.

COURSE III — Flotation Research

RECENT improvements in the facilities of the Institute's ore dressing laboratories make possible a somewhat broader attack on flotation problems, both of a purely practical and of a theoretical nature, than could previously be made. The segregation of flotation work in a separate room, the addition of microscopic equipment and new apparatus for particle size study are particularly significant improvements for flotation research of a fundamental nature.

The commercial development of the flotation process within the last fifteen years has had far-reaching effects on the mineral industry, and during that period flotation has risen in importance to become the predominating process for the concentration of ores. Its application to the concentration of metallic ores, particularly those of a complex nature, has made possible the mining of many ores which could not formerly be worked at a profit. Moreover, the concentrates produced by flotation have been in general materially higher in metal content than those which could be produced by other concentration methods from the same ores. As a result, the metallurgical treatment necessary for their reduction to metal has been relieved of much of the burden of removing impurities by chemical means, with a consequent simplification and cost reduction in the metallurgical process. Whereas a large part of the previous development of the flotation process has come out of trial and error experimentation following rather empirical principles, the process is now entering a stage in which important future developments may come out of more fundamental research following principles of physical chemistry, physics, and colloidal chemistry. The Institute is in an unusually favorable situation for this type of research, because of the personnel and facilities in these fields of science, from which flotation fundamentals may be drawn.

For the benefit of the reader who has had no contact with flotation, the basic phenomena of the present froth flotation process may be summarized as follows: If air bubbles are introduced into a properly prepared pulp or suspension of finely pulverized ore in water, particles of certain minerals will adhere to the bubbles, whereas particles of the other minerals will not show this tendency, and will remain separately suspended in the water. The air bubbles in rising out of the pulp carry with them particles of the one mineral or group of minerals, forming a mineralized froth layer which may be removed as a concentrate by suitable mechanical means. An investigation of this flotation process, from the standpoint of improving concentrate grade is now being carried on at the Institute by R. Schuhmann, Jr.

If flotation can be used to make a concentrate product containing practically all the valuable minerals in the ore and, at the same time, substantially none of the waste minerals, the metallurgy involved in reducing such a product to metal could be simplified and cheapened to a considerable extent. According to Professor Hayward of the Metallurgy Department, simpler metallurgical processes have already been developed in the laboratory for some such materials, but these processes are not applicable, in general, to present flotation concentrates because the impurity contents of the latter are too high.

Using present flotation technique, production of a final concentrate product with less than 5 or 10 percent of non-combined impurities (impurities not chemically combined with the valuable mineral) is somewhat unusual, and products approaching these low impurity contents are only obtained by several steps of flotation. For example, a single step of flotation on an ore may give a product containing 50 percent non-combined impurities; refloating this product may reduce the impurities to 25 percent, a third step to 18 percent, a fourth to 16 percent, and a fifth to 15 percent, etc. Such data illustrate the fact that the separation of minerals by flotation using present technique is by no means perfect, and there is a good field for further improvement. The final limit of impurity content reached in a multi-step flotation operation is dependent in part on the extent to which the valuable minerals and the waste minerals are mechanically "freed" from each other by crushing and grinding, but microscopic studies have shown that generally a certain part of the impurities remaining in the concentrate after several flotation steps are "free" and, hence, should be removable.

In the investigation now in progress a simple flotation separation is being studied in some detail to determine the causes of the behavior discussed above and, if possible, to find remedies for them. Two general possibilities are considered: (1) the waste mineral particles may be included in the flotation froth by mechanical means; (2) the waste mineral particles may float to a certain extent as do the bulk of the valuable mineral particles, that is, they have some tendency to become "attached" to air bubbles. Present knowledge of flotation gives some credence to the belief that the second cause can be remedied, in the cases in which it is shown to exist, by use of appropriate flotation reagents according to known principles, but the mechanical aspects of

(*Continued on page 22*)

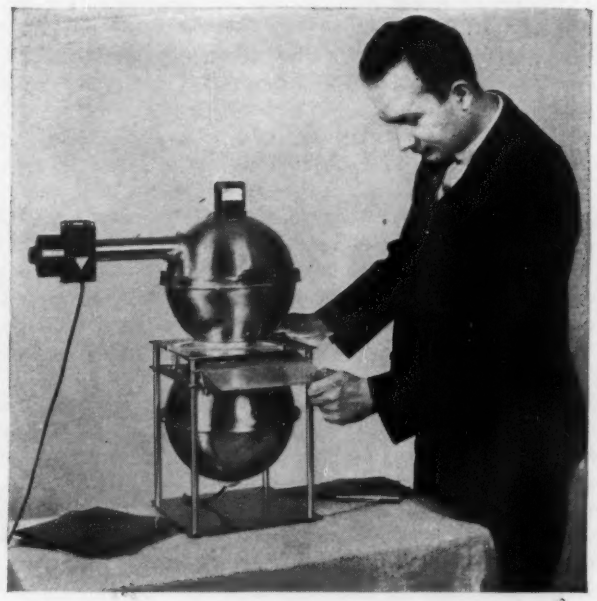
ENGINEERING DIGEST

LIGHT-SENSITIVE CELL REFLECTOMETER

THE measurement of the reflection and transmission values of translucent plastics, porcelain enamel, paint, acoustical, and other such materials is of great importance to the lighting profession. In order to determine these values accurately, a machine is required which can measure the reflection and transmission of light from and through different samples under equivalent conditions and be completely independent of the eye characteristics of the individual operators.

There are a number of machines partially fulfilling these requirements in use, at the present time, but the General Electric Company has constructed a new moderately-priced portable machine which, because of its use of the dry-disk light-sensitive cell, is not dependent upon visual observation. The reflectometer consists essentially of a ten-inch sphere, finished inside with a white matte surface. Located on the side of the sphere, slightly above the center line, is a tube containing a lens system and projection lamp. By means of this projector, a beam of light is directed onto an area, about two inches in diameter, on the opposite sphere wall. A swivel joint connecting the projector arm to the sphere enables redirection of the light beam from the sphere side wall to the test sample at the bottom of the sphere.

Two light cells are located in the sphere wall on either side of the beam, and the cells are connected in parallel to a microammeter located outside on top of the sphere. In the bottom of the sphere is a three-inch aperture that is placed over the flat sample to be measured. By means of a rheostat on the side of the lamp housing, which is in series with the projector lamp, the brightness of the sphere can be adjusted so that the pointer on the microammeter rests at full scale when the light beam is on the side of the sphere and the test sample is in position at the aperture. The beam is then focused on the sample and the second reading is taken as a per cent of the full scale or original reading. To prevent the direct reflection of light from sample to cell, a baffle is placed above the aperture between it and the cell.



To use the reflectometer for measuring transmission, another piece of mechanism is used. It is another sphere, and is also colored white on the inside. The second sphere is similar to the first in that it has an aperture in the casing but it contains a lamp instead of the cells. The two spheres are placed together so that the two holes coincide and the ammeter is again adjusted to full scale by adjusting the rheostat. The sample is inserted between the two spheres and is held in place by a floating pressure plate which can accommodate samples of varying thickness. The reading is again taken as a percentage of the full scale reading.

Since the reflectometer is portable, it can be taken to any wall or ceiling to measure the reflection value of that surface; it is only necessary that a lighting circuit be available.

— General Electric Review

BAHREIN ISLAND REFINERY

SINCE 1930, when Standard Oil of California sent a geologist on a wildcat expedition to the Persian Gulf island of Bahrein, the oil production of this island has increased until the field ranks today as one of the world's fifteen greatest. Under control of the Bahrein Petroleum Co., Ltd., a complete modern refinery has been recently erected to take care of the daily flow of 25,000 barrels per day of this new field.

The plant itself is self-contained on the island. It consists of two crude oil stills, a reforming unit, two cracking and coking units, an acid and clay-vapor treating plant for cracking gasoline, a lead sulfide sweetening plant for gasoline and kerosene, an Edeleanu sulfur dioxide plant for treating kerosene, and a special acid treating and re-run plant for power kerosene. The chief auxiliary plants on the island are the power plant, acid and lime manufacturing plants, wet slop dehydrator, and a leading plant for the addition of tetraethyl lead to gasoline. Finished products, shipped by steamer from the refinery, consist of several grades of gasoline and kerosene, of power kerosene, Diesel fuel, and bunkering fuel.

The native crude oil distilled in this refinery is at present a mixed base petroleum of about 30–35° A.P.I. gravity, and

resembles many American crudes. The native oil is first treated in the two crude stills. These are conventional in most respects, but include the somewhat unusual features of seperate re-run columns for cutting between light straight-run gasoline and heavy gasoline for reformer charging stock. Super-atmospheric pressure is required to condense the lighter cut, and to avoid imposing high pressure on the entire distillation unit the re-run feature was adopted.

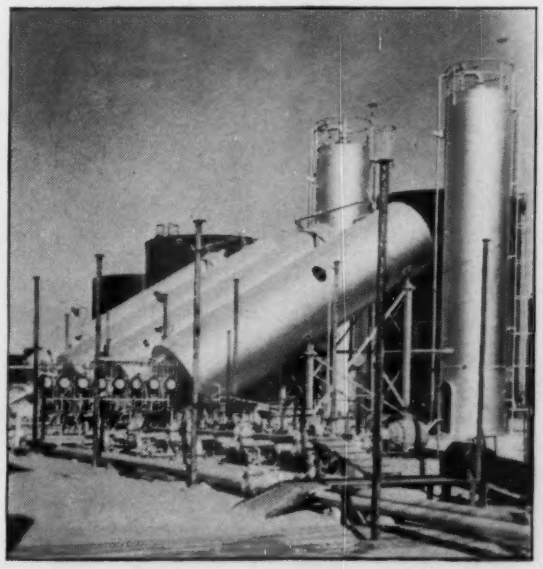
Vapors of the light straight-run gasoline and the heavy reformer gasoline pass directly from the fractionating tower to towers where they are clay treated before condensation and stabilization. From there they run to the cracking units where extra products are fractionated off. Three furnaces are provided for each unit, and these may be operated to produce liquid fuel, heavy pitch, or coke. Corrosion-resisting materials are generously employed. Furnace tubes are of 18-8 chrome-nickel steel and calorized chrome-molybdenum steel. Reaction and flash chambers are lined with thirteen per cent chrome-steel sheets, while lines and fittings subject to high temperature corrosion are made of from four to five per cent chrome-steel.

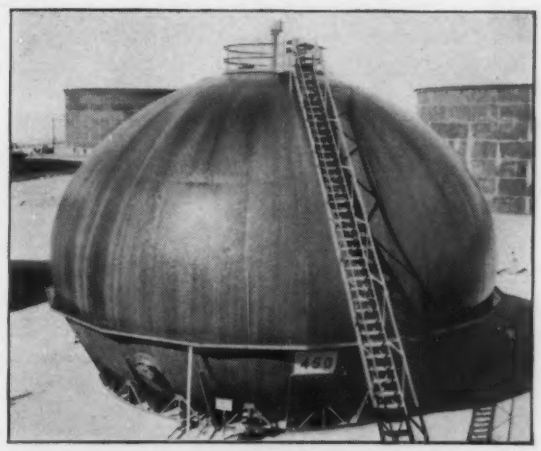
After being acid treated to provide a good stability characteristic, the gasoline or kerosene is sweetened by the Stratco process, employing lead sulfide. Separate treating lines and vessels are provided for each of the two products, although the parts of the plant devoted to storage and preparation of the necessary chemicals are not duplicated. The lead sulfide process was selected largely because of its simplicity and low chemical consumption, which are features of particular importance in a refinery as isolated as that of Bahrein.

A discussion of the technical aspects of the refinery would be incomplete without a description of one of the principal auxiliary features, namely, the power plant. Water containing 3000 parts per million of solid taxed the ingenuity of the design staff, and made necessary the adoption of unusual measures. Steam is generated for the plant at a pressure of 600 lbs. per square inch from distilled water exclusively. It is never used for process purposes, nor in any service where it will not be returned as makeup water. Moreover, the steam is used in condensing turbines to drive the hot oil pumps at the cracking units, and to drive the two 3000 kw. turbo-generators for the refinery's electric load.

The entire field is controlled through the Bahrein Petroleum Co., Ltd. by Standard Oil of California and the Texas Co. The efficiency and completeness of the field and the refinery can well be traced to them.

— Oil and Gas Journal





COTTON FIBER STRUCTURES

COTTON fibers present great opportunities for the study of the deposition of cellulose in cell walls, since they are single cells and the history of their growth may easily be followed. Because, however, variety and environment affect the behavior of the cotton cell, data obtained by different investigators sometimes disagree on a few points.

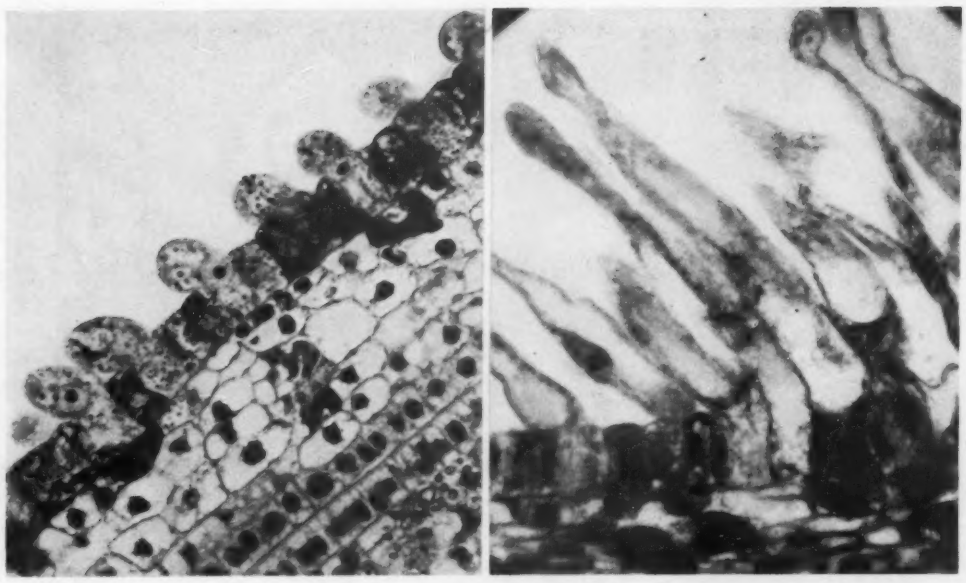
Each fiber is a single cell, originating as an outgrowth from the seed coat, and is attached to the seed only at its base. The fiber reaches its mature diameter very soon, but it takes from fifteen to twenty days for its elongation, during which period only the primary wall is formed,. the secondary wall being formed after elongation has ceased. The primary wall is composed of cellulose, pectin, and probably some waxes. The wall alone in the mature cell contains pectin. Although cellulose is present in this wall from the first day, it is not clearly apparent during the early stages of development. For this reason, some investigators have suggested that the material of the primary wall is not cellulose but some closely related substance.

In structure the cellulose of the primary wall forms a network of fine strands which cross each other frequently. When died for visibility, these threads are anistropic, and it may be seen that they compose two opposing, spirally-wound systems, the thread making an angle of about 70° with the major axis of the fiber. There is some evidence that there may also be present a third system which is composed of transverse strands of cellulose. The pattern of the primary wall persists during the period of lengthening, though some cellulose continues to be added to the wall, but it is impossible to determine just how the added cellulose has been deposited.

The secondary wall of fibers does not begin to appear until the fiber has almost completed its elongation. When stained with chlorozinc iodide, the wall reveals itself as a layer of strands, spiraling at an angle of about 30° with the major axis. Characteristic of this wall is the presence of reversal in the spiral pattern, since the spiraling changes from right to left or vice versa as many as fifty times in the whole fiber. These reversals may take either the form of a mere bend in the spiral pattern or may represent the intersection of spirals of opposite direction.

Until a few days before the boll opens, the innermost side of the fiber wall continues to take on cellulose. When the ball opens, the fibers are allowed to dry, and the wall becomes twisted in the direction of the majority of the spirals of the strands in the cell wall. Reversals in the strand spirals are reflected in the reversing of the twist of the walls.

It has been found that although there is little difference in the time for fiber elongation of flowers opening at different stages of summer, those which opened early, matured in a shorter time than those which opened late, the formation of



the secondary wall representing practically all of the difference. The early fibers also have wider growth rings and less of them than the late cotton fibers. These growth rings are layers of cellulose of different densities. It is not fully known whether they are the result of intermittent growth, or continuous growth under changing conditions. Since under continuous illumination and constant temperature there are no growth rings, light and temperature certainly seem to have some bearing upon their formation.

There are, at present, two theories upon the structure of cellulose. One states that long cellulose chains are bunched parallel to each other to form bundles or micelles, which are bound together by other overlapping cellulose chains. The other theory, the ellipsoidal hypothesis, assumes the origin of visible cellulose units in the protoplasm. These units are coated with some type of cement, and combine with other units to form chains which migrate through the protoplasm to the cell wall where they become cemented.

There is some evidence to support the ellipsoidal hypothesis, but there is still much which that theory fails to explain. The miceller hypothesis, on the other hand, seems to account plausibly for all observations.

Industrial and Engineering Chemistry

PLASTIC MARQUETRY

RECENTLY, a new surfacing material having the appearance of marquetry has been introduced. Its durability, decorativeness, and flexibility make it a material which has aroused much interest among designers and manufacturers.

This product is available in several styles, all of which are processed alike. Essentially the process is one of applying a surface of cellulose acetate to woven strips of wood veneer. In order to form a strong pliable sheet, the whole is fused under heat and pressure. This acetate surface may be applied to both sides of the sheet, but the natural wood is generally left on one side in order to facilitate cementing.

The many styles of this material are made by variations in weave, by use of metal strips in addition to wood, by use of tinted surface plastics, and by leaving open spaces between the strips of veneer. In the last case, the product must be backed with a sheet of cellulose.

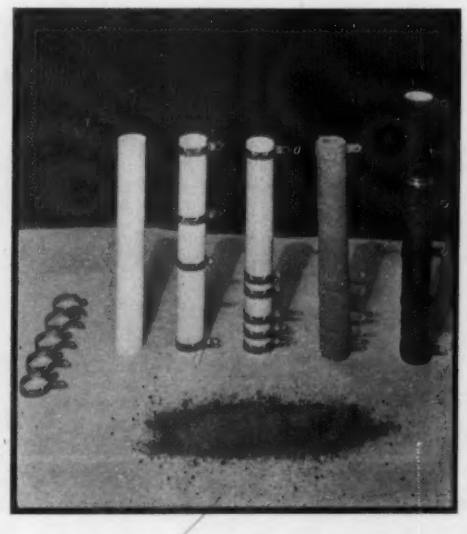
The new material has many possible uses. Its pliability makes it of value to designers as a decorative wood on curved surfaces, such as recesses or even columns and pillars. The almost indestructible surface of the material and its fine appearance give it an outlet in application to furniture. The novelty field also will provide an extensive market, for this material can be used to good advantage in handbags, jewelry boxes, and compacts. It may also be used for interior decoration in airplanes, where its lightness and flexibility can be employed to maximum advantage, and in automobiles, where it will provide an easily cleaned interior surface. Another market may be found in the employment of this material for surfacing small, unpowered, or lightly-powered boats. Last summer a canoe was so constructed, and tests indicated that it was superior to present surfacing materials in many respects.

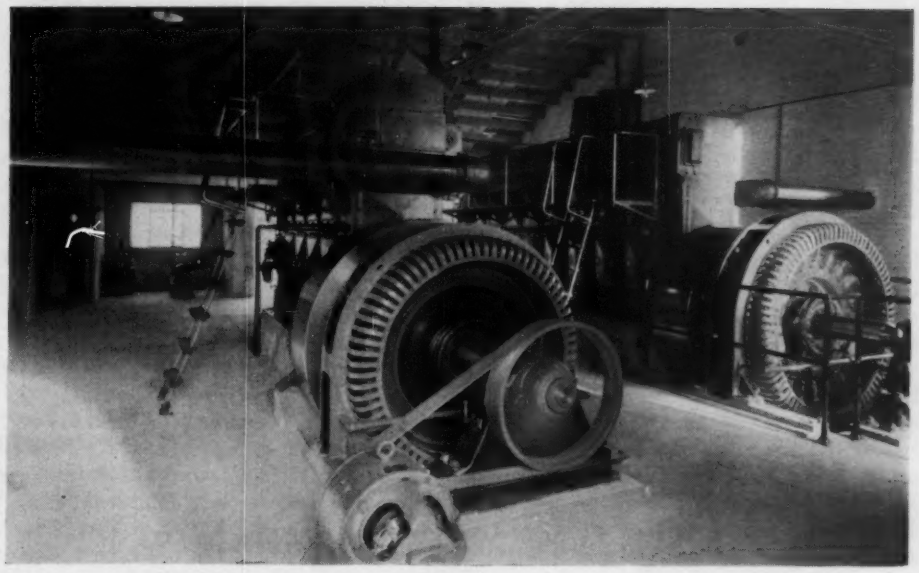
—Modern Plastics

IMPROVED ELECTRICAL RESISTANCES

THE common vitreous enameled electrical resistor, used extensively today, though nearly perfect, is still the subject of extensive research. A good electrical resistor must itself resist the corrosive effects of fumes and chemicals, various changes of climatic conditions, and not only frequent changes in temperature but continuous operation at high temperatures. The vitreous enameled resistor fulfills all these conditions. It consists chiefly of a cylindrical ceramic tube which serves as a form for a winding of resistance wire and as a support for such terminals as are necessary to make the proper electrical connections to the resistor wire. The entire resistor (with the exception of the terminal lugs or ferrules, to which external connections are made) is then covered with a protective layer of vitrified enamel.

The main weakness in the vitreous enameled resistor, as it existed about 15 years ago, was in the connection between the resistance and the terminal straps. This was frequently broken or loosened during manufacture. One of the chief causes of this lay in by the difference in temperature coefficient of expansion of the ceramic and the resistance wire.





The failure occurred during the firing process. The problem was to find a suitable resistance wire with the same temperature coefficient of expansion as the ceramic used. The wire finally chosen was a nickel-chromium alloy. It had a resistivity of 673 ohms per circular mil-foot, ideally suited for industrial use, and was immune to the corrosive actions electrical resistors are subject to. After further research a ceramic was found whose temperature coefficient of expansion matched that of the nickel-chromium alloy and whose characteristics were suitable for use with electrical resistors.

Another cause of failure came from the corrosive action occurring at the connection of the terminal straps and the resistance wire. The copper straps, originally used, oxidized at the high temperature of annealing, and eventually loosened or broke the circuit completely. This and other troubles led to further research which pointed to Monel metal as the ideal material for terminal straps. This metal resisted the corrosive actions the strap is subject to, and in addition has about the same expansion coefficient as the ceramic and resistance wire.

These improvements practically eliminated the failures in vitreous enameled resistors which previously has been as high as 40% during manufacture and an additional 20% in the field.

—Inco

FLAME SOFTENING AND HARDENING

THE use of oxy-acetylene flame for cutting purposes produces hardening of the severed edges on certain structural steels. Previous to the present time, if the hardness was undesirable, the flame cutting process could not be used unless large capacity heat-treating furnaces were available. To overcome this difficulty an attachment has been added to the cutter which heats the surrounding area to a high temperature, thus reducing the quenching action of the cold base metal, which causes the hardness; likewise the speed of the air quench is retarded. The device consists of a multi-flame head, which may either precede or follow the cutting flame, thereby making the flame cutting of steels possible without impairing the physical properties of the cut edges.

This hardening caused by the flame, although generally undesirable for cut edges, is useful for bearing surfaces, and may be advantageous when a hard "case" is required. By applying an oxy-acetylene flame, the surface may be hardened without altering the structure of the inner part.

—Oxy-Acetylene Tips

POWER DEVELOPMENTS

A number of new types of power units have been introduced to the rock products industry, thereby simplifying the problem of a continuous, cheap, and efficient source of power. Originally, because of their positions on the outskirts of cities and towns, the plants of this industry depended upon their own power, such as steam driven electrical generators, or even steam power itself. Electric power was not practical, because of the peak demands and the minimum charge imposed.

Among the newest introductions to the industry are the Diesel engines, which are not only used to drive generators, but in some cases to provide power directly. They have proven to be economically practical, because of low fuel consumption combined with the necessary power output. Diesels are used for all types of jobs: crushing, electric shovels, screening, cranes, and, perhaps most important, dredge operations.

—Rock Products

ACCURATE TIMER

THE increasing demand in the timing of races and speed events of all sorts has led to the development of timing clocks, operated by photoelectric cells. The new device shows a great advance in accuracy, for it will measure accurately to a thousandth of a second, in which time a body moving fifty miles an hour will travel less than an inch. In timing races by hand, an error of a fifth of a second can be expected. In this period of time a body travelling fifty miles an hour will cover more than fourteen and one-half feet.

These timers, which are placed at the start and finish of a course, consist of a light source on one side of the track, and on the other a photoelectric cell, to which a beam of light is thrown. The clock is started by an interruption of the beam at the starting post, and is stopped by an interruption in the finish beam. An additional bit of equipment, which is often used, is a slow motion picture camera, which simultaneously photographs the timing clock and the contestants as they cross the finish line.

—General Electric

RESEARCH IN REVIEW

(*Continued from page 17*)

the problem have not yet received as much attention.

Significant results have been obtained in determining the relation of rate of "flotation" of supposedly non-floatable mineral particles to the particle size, and in comparing these rates with the simultaneous rates of flotation of floatable mineral particles of the corresponding particle sizes. Inasmuch as the particle sizes dealt with in flotation range from about 100 microns down into the colloidal size range, sizing on the basis of particle settling velocities in water is the most convenient method of isolation of size fractions for separate study. No attempt has been made to fractionate by size below about 2 microns (calculated by Stokes' Law for galena particles of specific gravity 7.5 at lowest settling velocity used), and the results have indicated that all particles with settling velocities below the limit corresponding to this size may be grouped together as far as their flotation behavior is concerned. The particle size fractionations made so far in this work have been on the basis of settling velocities of par-

(*Conitnued on pape 28*)

FINE GRAIN

(*Continued from page 6*)

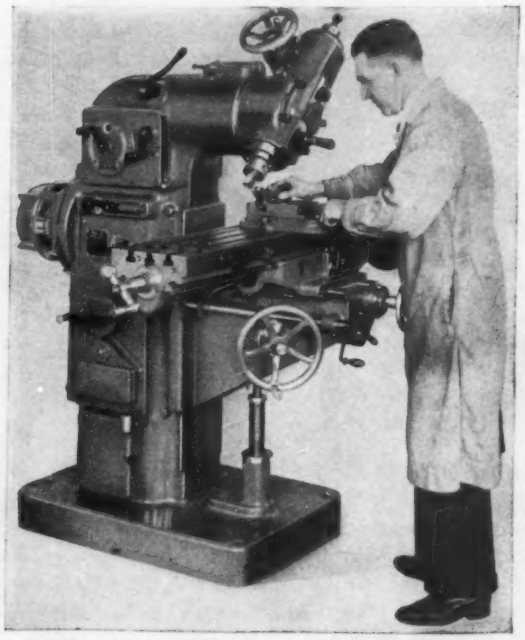
Benzoic acid
Boric acid
Salicylic acid
Pinakyptol green
Iso-propyl alcohol

Other attempts have been made to secure the benefits of fine grain without loss of speed and in some cases to avoid also possible toxic hazards of paraphenylenediamine. In some cases, these attempts have been made under such commercial conditions that full details have not been published.

In view of the fact that much of the "graininess" of the finished film appears due to clumping of grains, many attempts have been made to reduce final "graininess" by devices designed to reduce the swelling and softening of the gelatine with a view to preventing clumping. These methods have been tried with many different reducers and have been of little avail. These additions have included compounds tending to hinder the diffusion of the developer into the emulsion layer. The results have been quite generally disappointing.

The suggestion has been made that the secret of fine grain development is long development times for normal contrasts. This is in agreement with the fact that the fine grain paraphenylenediamine formulae normally required rather prolonged development. Other methods of prolonging development have been tried, most of which have been of little value. As one example a metol formula was used at pH 6.7, which increased the developing time to 2 hours at 68° F. The grain obtained was finer than normally obtained by borax developers, but was not equal to that produced by the paraphenylenediamine formulae.

(*Continued on page 27*)



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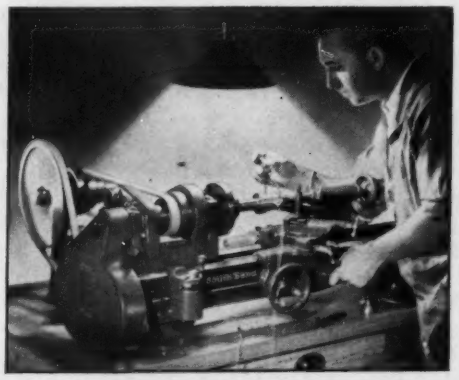

Illustrated above is the New 1938 Model 9" x 3' South Bend WORKSHOP Motor Driven Precision Back Geared Screw Cutting Engine Lathe, price $117., F. O. B. South Bend, Indiana.

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DEVELOPMENT OF PHOTOGRAPHIC CAMERA

(*Continued from page 11*)

produced were so small that they could hardly be satisfactorily viewed in the hand, and the quality of films, lenses, and enlarging apparatus was so deficient that the production of enlargements of satisfactory size from tiny negatives, if not impossible, was impracticable, even for skilled workers.

As a matter of fact, Barnack in his invention was somewhat ahead of his time, and his camera, though backed by a powerful and energetic optical firm, was not received with much favor at first and sold slowly in its first years. Barnack, however, had foreseen possibilities in photography which were not apparent to his contemporaries, and his original cameras were so designed that all kinds of changes to meet changed conditions have been applied to them' and the very earliest models can be changed to embody every improvement made since without discarding the original box.

Fortunately for the makers of the Leica camera, as this instrument was named, the motion picture camera had become popular and opticians had made great advances in speeding up lenses. Where *f*:4.5 had been esteemed the limit of performance for hand camera anastigmats, lenses of the speed *f*:3.5 were introduced gradually, but the motion picture camera with its small size of film opened the way to the production of short focus anastigmats of speeds which were previously deemed incredible. Limits of *f*:3, *f*:2 and even *f*:1.5 were conquered in turn and the miniature camera was provided with lenses of a speed sufficient to cope with any ordinary photographic problem.

The makers of films had resisted every effort on the part of photographers to obtain panchromatic roll film, on the unjustified theory that development by green light was commercially impracticable and that the amateur sale of such films would be unremunerative. The motion picture industry, however, demanded and obtained faster and faster, more and more color-sensitive, and finer and finer-grained films, and the Leica camera profited by all the increases in film speed and quality. By 1931 the miniature camera was well established and the original model had competition in all directions. The problem of mechanical and chemical handling of the small film was attacked by both professional and amateur. Enlargements in the old days of amateur photography had been on the order of 2x, 3x, 5x. The miniature camera enthusiast desired to and succeeded in enlarging his 1 by 1½ inch negative to make pictures 3 feet, 5 feet, eventually 10 feet in length, and to do this he had to solve problems of chemical cleanliness, of mechanical handling, of fine grain development, which offered a wide field for experiment, but were most satisfactorily solved.

The use of short focus lenses solved the question of depth of focus, and between increased lens aperture and increased film-speed, practically no conditions exist today which preclude successful photography. From airplanes, cities may be photographed at night. The quickest action on the theatrical stage can be stopped with the ordinary theatre illumination, and few photographers would hesitate to attempt to photograph the proverbial black cat in a coal cellar at midnight.

What is the future of the miniature camera? The enthusiast and the experimenter have solved all the problems of the

(*Continued on page 28*)

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PROCESSING FILM

(*Continued from page 9*)

serted in the exposure scale test negative. Prints on each printing machine from this 9,000 cycle negative are inspected daily with a microscope. One familiar with the appearance of sound tracks viewed under a microscope can distinguish a slight loss of definition much more easily and with a greater degree of certainty than could be detected by ear. Therefore, visual inspection by the microscope is relied on for maintaining high definition of sound rather than listening to the sound on reproducing equipment.

The developing bath characteristics are checked every hour. Each day sufficient sensitometer strips are printed on the standard raw stock for the tests of the following day. It has been found that latent images on positive emulsions fade most rapidly during the first 12 hours after exposure, and then more uniform and less rapid aging takes place. Therefore, the sensitometer strips are allowed to age 12 hours before being used. Each hour during operation a strip is sent through the developing bath at a constant standard speed equivalent to a specified time of development. This sensitometer strip, when its densities are read and plotted, gives the characteristics of the developing bath. Should there be any variation from the standard, the chemist can see at a glance what properties of the bath have changed. He interprets the shape and characteristics of this curve in terms of amounts of chemicals to be added or subtracted from the developer replenishing solution.

The quality of any motion picture print is eventually judged by what is seen on the theatre screen. Therefore, every foot of film produced is inspected by projection after being processed. The inspector is able to detect any defects from the audience's point of view, since he sees the film under similar conditions.

The quality of the projected picture is dependent upon many factors other than those governing print quality. The characteristics of the light source in the projector, the optical system through which the light passes, the spectral reflectivity of the screen, as well as the characteristics of the observer's eye, are some of the factors on which the final print quality depends. For the past few years, the Standards Committee of the Society of Motion Picture Engineers has been attempting to standardize many of the factors upon which screen quality is dependent. However, because of the great variety of conditions existing in the theatres, this problem is far from being solved. The only present recommendation refers to screen brightness, and even this is under discussion. The projection screens in the laboratory are maintained at the recommended brightness of 10 ($\pm$ ½) foot lamberts with the projector running, and with no film in the aperture. These measurements are made daily with a Weston illuminometer, filtered so that its spectral response is similar to that of the human eye.

The screens for final inspection subtend an angle at the inspector's eye small enough so that the projectionist is able to see all parts of the screen simultaneously. This is to enable him to pick out any defects, such as scratches, dust spots, etc., which might be present on any portion of any single frame of the picture. The inspector gives a rating to each reel, signifying the physical, photographic, and sound qualities.

The control of the developing and fixing baths is semi-automatic. Routine tests are made to control the properties of the baths within narrow limits.

The developer is circulated from a central reservoir, through the processing units, and returned to be recirculated.

(*Continued on page 26*)

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PHOTOGRAPHIC EMULSIONS

(*Continued from page 13*)

emulsions to wave lengths which are absorbed by solutions of these same dyes in such a non-aqueous solvent as methyl alcohol. Other observations have shown that the state of these dyes, in aqueous solution is different from that in non-aqueous solution and that in water, they may exist as agglomerates or aggregates. The new studies not only corroborate the observation that changes in state occur in aqueous media but demonstrate, as well, that the state of the dye adsorbed to silver bromide closely resembles that shown in certain aqueous salt solutions such as potassium bromide. The term, "aggregated adsorption", has been coined to describe this condition. By this terminology, it is meant to say, simply, that the silver halide in an emulsion takes up sensitizing dyes in such a way that the light absorption curves of the emulsion are similar to the curves given by the "aggregated" dye as it exists (perhaps in a colloidal state) in aqueous salt solutions.

The recently published data emphasize the fact that the concentration of sensitizing dyes has a marked influence on their effect. There appears to be a definite correlation between the silver halide grain surface and the amount of dye in a solution or in an emulsion. In general, the sensitivity rises to a maximum with increasing dye concentration and then begins to fall off rapidly. At maximum sensitivity it was found that at least 99 per cent of each of several dyes used was adsorbed to the silver halide grains. The addition of more dye than necessary to obtain this maximum sensitivity was accompanied by a corresponding rise in the concentration of unadsorbed dye and by a decrease in sensitivity. It has been found that there is a strict proportionality between the concentration of the dye and the total surface of the silver halide grains in a given emulsion. Calculations show that this relationship is in accord with the hypothesis of a uniform monomolecular layer of dye covering the surface of the halide grains. This very interesting notion suffers from the disadvantage that it appears to be at variance with the evidence which has been found in support of "aggregated adsorption".

By way of reconciling these divergent points of view, it can be urged that the calculations leading to the conception of a monomolecular layer of dye on the silver halide grains may represent nothing more than a coincidence. For example, at present there is no way of showing that the dye is not adsorbed in the form of multilayer patches, or "aggregates." Against this possible but somewhat fortuitous distribution, it is more satisfying to conceive of a uniformly adsorbed monomolecular layer in which the molecules of the dyes are so oriented that they can interact with each other, thus increasing sensitivity. Such an interaction would give the effect of "aggregates" without requiring actual physical agglomeration of the sensitizing dye and be in accord with the conception of "aggregate adsorption."

The story of the relationship between sensitizing dyes and silver halides ceases at this point and its continuation must rest on the publication of still newer chapters in the scientific journals. For the moment it is clear that within half a century after the observation was made that various organic dyes, particularly the cyanines, increase the sensitivity of photographic emulsions to infra-red radiation, there has grown up a whole new field wherein the skill of the photographer can be practiced. Lengthened is the scope of "photographic" eye. Improved is the photographic plate for infra-red spectroscopy. New data are available for testing certain expanding theories. A challenge has been put to the physicist and to the chemist to seek out the mechanism by which sensitivity is increased. Progress has followed their efforts in this direction, and more is promised.

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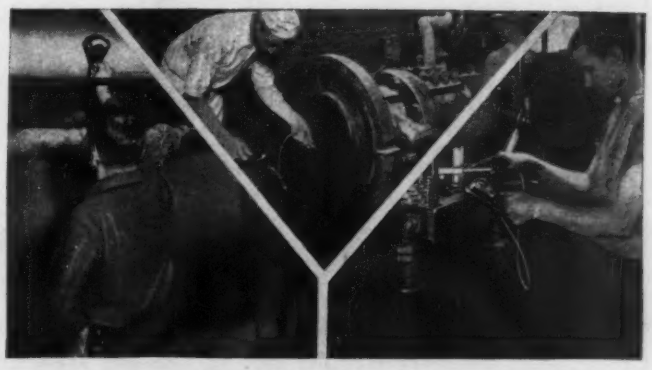

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PROCESSING FILM

(*Continued from page 24*)

Replenishing solution is added to this central reservoir to compensate for the oxidation of the developer in processing. Small quantities of developer are "bled off" continuously to maintain a constant volume. The bulk of the bath is used indefinitely. The entire system is air-sealed to prevent oxidation. All materials in contact with the developing solution are corrosion-resistant.

A developing solution usually consists of four components; namely, a reducing, or developing agent; an accelerator, usually sodium carbonate; a preservative, usually sodium sulphite, which prevents oxidation; a restrainer, such as potassium bromide. As stated previously, the concentration of these ingredients is judged by the characteristic curves determined by the developing tests. Should it be necessary to modify the developing bath characteristics, the formula of the replenishing solution is adjusted to bring about the desired condition.

The temperature of the developing baths is maintained constant by thermostats in the feed lines to the developing units. Inside the central reservoir are coils in which hot and cold water may be circulated. The flow and temperature of the water in these coils are regulated automatically to maintain a constant temperature of 70°F±¼° in the developing units.

The circulatory system for the fixing bath is similar to that of the developing bath. The fixing bath is circulated from a central reservoir by means of centrifugal pumps, through hard rubber pipes to the fixing tanks. The fixing bath, in its return from the tanks, is sent through a silver recovery system, and then back to the central reservoir.

The temperature control of the fixing bath is automatically controlled by thermostats in the feed lines. These thermostats regulate a unit which increases or decreases the temperature of the solution in the feed lines of the fixing bath, maintaining the temperature at 68° F±2°.

The purpose of the fixing bath is to dissolve the undeveloped silver halide on the film. The precipitation of sulphur, or aluminum sulphite, sludge, and hardening, are problems intimately connected with the processing of any quantities of film. The fixing bath must solve these problems satisfactorily. The properties, other than fixation, of the fixing bath are so closely related that changes in one component may change various properties in the bath. It may generally be stated, however, that the property of the alum in the bath is to produce satisfactory hardening; the property of the acid is to prevent precipitation of aluminum sulphite when there is a carry over of developer from the developing bath; and the sodium sulphite prevents the precipitation of sulphur from the fixing bath by the acid.

The fixing properties of the bath are easily tested by measuring the time required to clear the silver halide from the film. It can be observed while production is in progress. The fixing properties are always maintained so that total clearing takes place in less than ⅓ the total time the film is in the fixing bath.

The hardening properties of a fixing bath must be sufficient to prevent undue swelling of the gelatin in the wash water, with the subsequent difficulty in drying; as well as to impart a mechanical ruggedness to the emulsion so that it can be handled and projected without being damaged easily. The relative hardening is measured every two hours by determining the temperature at which the emulsion melts in water.

The sodium sulphite concentration in the fixing bath is maintained by the carry over from the developer. The average concentration is about 2 grams per liter.

For constant quantities of sulphite and alum, there is a concentration of acetic acid which will produce maximum hardening. Too great a concentration of acid is likely to cause sulfurization of the fixing bath, or too little is liable to result in precipitation of aluminum sludge. Determination of acidity

(*Continued on page 28*)

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FINE GRAIN

(*Continued from page 22*)

Greater success has been obtained with metol and hydroquinone as reducing agents by the addition of ammonium chloride as a silver halide solvent to developing solutions. This means of securing fine grain was described in considerable detail in the *British Journal of Photography*, volume 51, pages 866 and 867, 1904, by A. and L. Lumiere and A. Seyewetz. They suggest the addition of relatively high concentrations of ammonium chloride, from 150 to 200 grams per liter and find that slow very fine grain development results. They suggest that the ammonium chloride dissolves the silver halide and that is subsequently deposited to form the final image by a process which is essentially physical development. In this connection it is interesting to note that U. S. Patent 2,053,516, issued September 8, 1936, covers in its first claim a fine-grain photographic developer comprising a metol-hydroquinone developing agent and ammonium chloride in amount sufficient to produce a fine grain image.

Only a few direct comparisons of the results obtained with different fine grain formulae have been published. Some other formulae have equalled but none have shown marked advantage in "graininess" over the results obtained with the paraphenylenediamine formulae.

In some cases, considerably higher effective emulsion speed has been claimed, but these results have not always been verified by other workers. This difference between workers may be due in part to different methods of handling exposure meters, as the use of exposure meters on different scenes is not sufficiently standardized to lead to exact checks between users. Another factor involved in this speed estimate of emulsions and developers is the judgment of the desired negative quality. Some of the most successful enlargements have come from negatives not only low in contrast, but also quite low in density. A person working for that type of negative may quite fairly estimate the emulsion speed higher than a person working with negatives of more ordinary density characteristics. These factors do not explain all of the differences found in the claims for and tests of various fine grain developers on the market, but they account for some of the discrepancies.

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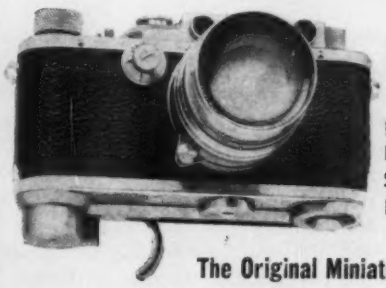

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DEVELOPMENT OF PHOTOGRAPHIC CAMERA

(*Continued from page 23*)

35mm film, and the conclusion has been arrived at that the miniature camera has many uses, but that certain of its limitations are unnecessary. Commercial statistics would seem to indicate that the 35mm film is losing somewhat in popularity in favor of a film somewhat wider. Cameras taking a picture about 2¼ to 2½ inches square seem to have some mechanical advantages, and it would not be making too rash a guess to assume that somewhere an ardent constructor is developing a camera which will use 70mm perforated film for either a square or oblong picture which will combine the advantages of the present miniature with a film of four or five times the area, in order to make enlarging somewhat more simple.

RESEARCH IN REVIEW

(*Continued from page 22*)

ticles in their actual state of dispersion or flocculation in the flotation operation, as far as experimentally possible. As yet no attempt has been made to evaluate factors affecting the state of dispersion and the measured size distribution, although this aspect of the problem may justify study later.

On the basis of the data which have been obtained, correlating particle size, particle settling velocity, and flotation rate, it seems very possible that certain modifications in the flotation apparatus, and to some extent in the flotation process itself may effect a reduction in the rate of "flotation" of the "non-floatable" mineral particles. Investigation of these possible modifications is now in progress.

PROCESSING FILM

(*Continued from page 26*)

is made every two hours by titration against a standard alkaline solution.

Boric acid is included in the fixing bath since it increases the life of the bath by preventing the deposition of aluminum, and by extending the pH range over which hardening occurs. As it is not used up, the proper quantity is restored when portions of the bath must be discarded.

The recovery of silver from the fixing bath is accomplished by the addition of sodium sulphide, which precipitates silver sulphide. The precipitate is removed by pumping the suspension through a filter press. The desilvered fixing bath is returned to the circulatory tank. This process is continuous, and maintains a silver concentration of less than .05 oz. per gallon of fixing bath. Approximately 1200 ounces of silver are recovered from every million feet of film processed.

The wash water is tapped directly from the city water supply. Its temperature is automatically controlled by thermostats in the feed lines, a constant temperature of 68°F being maintained. Film strips are tested twice daily to insure that the film has been washed sufficiently to remove all traces of chemicals from the fixing bath.

The entire plant is air conditioned. The requirements of various parts of the plant differ radically, therefore the relative humidity and temperature are controlled accordingly. The dry cabinets through which the film passes on leaving the rinse water require a low relative humidity, so that the water will be absorbed by the air from the film. On the other hand, negative printing rooms require a high relative humidity to prevent curling of the negatives, and static difficulties when printing.

These control methods may seem rather elaborate and somewhat expensive, but they have made possible the mass production of motion picture prints, and have reduced the cost of motion picture printing, exclusive of the cost of raw stock, to less than one-fifth of what it was a decade ago. The science of motion picture engineering is developing rapidly, and today can point proudly to a concrete mass of achievement.

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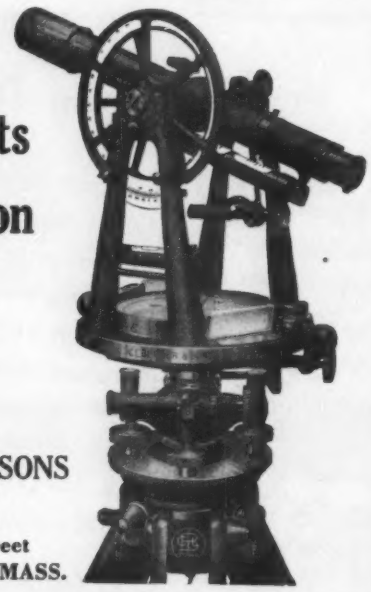

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Whether it be in purchasing materials —or in manufacturing the 43,000 items of telephone apparatus—or in distributing all this equipment to the Bell companies, Western Electric is always seeking the better way. As a result it has a progressive record of methods developed, products improved, economies effected, and costs lowered.

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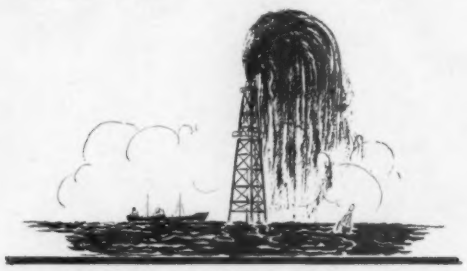
G-E *Campus News*

TEST ALUMNI DAY

TO celebrate the third annual reunion of engineering graduates of General Electric Test, men all over the world gathered in groups to listen to the international radiobroadcast of the reunion at Schenectady, N. Y. Officers and prominent members of P.T.M.., or Past Test Men's Association, sent greetings to their fellow Testmen over the General Electric shortwave stations, W2XAD and W2XAF.

More than 15,000 men have graduated from G-E Test—a course which enables them to supplement

their theoretical knowledge with a practical training. Test graduates today hold many responsible positions in the Company. Others have gone into every walk of life—engineers, lawyers, utility executives, farmers, industrial leaders, bankers, and many other professions. There is, however, one tie which binds them all—their experience "on Test," and to many of them that experience is recalled with somewhat the same enthusiasm as days in college.



OIL FROM WATER

DOWN on the shores of Lake Maracaibo in the steaming jungles of Venezuela, the Dutch Shell Company owns rights to a fifty-mile frontage. Here it has drilled hundreds of wells to make available the rich oil found in deposits ranging from 1500 to 5000 feet below the lake surface.

The natural gas which accompanies the oil deposits has for years been used to power the wells. In spite of this cheap source of power, General Electric engineers under the supervision of E. E. Thomas, Kansas State '22, were able to convince officials of the Dutch Shell Company that it would be more economical in the long run to use electricity instead of natural gas and gas engines for operating power. As a result, a high-voltage line will be erected along the lake shore, from which step-down transformers will distribute current to the motors in the producing areas.

The Lago Petroleum Company has wells in a section paralleling the Dutch properties and extending ten miles out in the lake, which has already been electrified. The combination of these two companies makes the largest electrified system of its kind in the world, from which 400,000 barrels of oil are shipped daily to refineries in Aruba and Curacao, N.W.I.

WHISTLING GASES

GASES are liquefied to be used as cooling agents and to conserve storage space. Chester W. Rice, Harvard '10, consulting engineer in the Schenectady Works of the General Electric Company, has developed a method of thus processing gases more readily by making them whistle.

To liquefy a gas by this method, it is necessary to compress it to 3,000 pounds per square inch, cool it, and pass it through a series of tubes into a liquefying chamber where the pressure is released through a valve in the form of a whistle, producing a further escape of heat energy. Mr. Rice's whistle is so pitched as to convert the greatest amount of heat energy into sound energy. To be effective, however, the sound energy must be carried away from the liquefying chamber.

Developments such as this are being made by college graduates who were at one time "on Test." Many of them have been off the college campus but a few years and are entering a career in one of the many business and engineering fields in the General Electric Company.

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